CONSERVATION AND MAINTENANCE OF TEMPLES UNDER THE HINDU RELIGIOUS AND CHARITABLE ENDOWMENTS DEPARTMENT, TAMIL NADU

WORKING DRAFT

ACKNOWLWDGEMENTS

This draft wouldn’t have been possible without the various inputs and expert opinions from several stakeholders who share a common vested interest in the conservation and maintenance of temples in Tamil Nadu.

The contribution of conservation expert Dr. Arun Menon, Co-ordinator, National Centre for Safety of Heritage structures, IIT Madras, and member of ICOMOS (International Council on Monuments and Sites), in putting forward a conservation process and structural conservation methodology for the heritage temples of Tamil Nadu discussed in the manual is irreplaceable. The involvement of conservation architect Hareesh Haridasan, Senior Project Officer, National Centre for Safety of Heritage structures, IIT Madras, also a member of ICOMOS India has been immensely beneficial to the document.

The contribution of the agama experts viz. Swaminatha Sicvachariya, Mayiladudurai for Shiva Agama, S.Prasanna Dhikshidar, Mannargudi for Pancharatra Agama, Seshacharilu, Thiruvahindipuram for Vaikanasa Agama must be mentioned in throwing light on the attitude towards conservation and renovation as discussed in the agama shastras. The contribution of Padmashri.Muthaiah Stapathi, was instrumental in explaining the traditional temple building practices in the shilpa shastra.

The document benefited from the inputs from R.Balasubramaniam, Assistant Superintending Epigraphist Dept. of Archaeology. The document has immensely benefitted from the review and critical inputs from Dr.D.Dayalan, Ex-Director, Archeological Survey Of India(ASI) and Dr.Sreelatha Rao, Assistant Superintending Archaeological Chemist, ASI.

ABSTRACT

In order to completely understand the process of conservation in temples, it is important to understand the traditional practices of building temples, in terms of the materials and construction techniques used, the traditional systems such as agama shasthra and shilpa shastra that govern the means of construction as well as the activities revolving around the temple structures. The first part of the document titled as **Introduction**, deals with a brief understanding of these concepts, the architectural forms in the temple complex, their symbolic meaning as well as their construction techniques. This section also discusses the classical concept of conservation and renovation in temples as discussed in the agama shastras. This throws light on some of the important practices that are an inherent part of the conservation of temple structures, such as the creation of balalayam and other rituals.

The second part of the introduction discusses the factors causing deterioration in heritage structures, for an understanding of threats and possible causes of decay in the temple structure.

The last part of the document is put forward as a **Draft Conservation Manual**, where the approach towards conservation is discussed under **Conservation Policy**. Noting that the manual is drafted for the large number of temples under the HR&CE Depatment, each with its unique layers of history and different challenges in terms of damages to the structures, it is prerogative that the manual is able to accommodate a variety of challenges in the conservation practice. Hence, the manual puts forth a conservation process, which must be followed before any maintenance work or whenever there are any signs of distress noticed in a temple structure. Following the conservation process, the process of structural conservation of temples is discussed.

The chapter on **Structural conservation** has three sections; the first section discusses the **Typical distresses in temple structures**. Understanding these distress situations can assist in identifying any signs of decay or deterioration in the temple structure that may affect the safety of the structure. The second section deals

with the **Diagnosis of Structural Distress**, which throws light on the different means of investigating the causes and nature of structural damage in the temple, citing the possible methods and tools that must be used in diagnosing the structural distress prior to initiation any conservation procedure on the temple structure. The next section introduces the possible **Interventions For Structural Distress**, highlighting the important techniques and methods that are to be implemented in the structural conservation of temples including, underpinning, grouting, re-pointing, stone stitching, to name a few.

The final part of the manual discusses the **Maintenance** protocols that must be followed in all temples of historic value including those that are structurally stable. The section on maintenance also discusses the maintenance and **preservation of murals and inscriptions** within the temple complexes.

Towards the **Conclusion**, the document proposes a step by step process to undertake any conservation work using the manual. A flowchart summarizes the **conservation management process** citing alongside, the parts of the manual to be referred for each step. Directions for further research to be taken up that will help in the conservation and maintenance of the temple structures are also proposed in the conclusion.

DEFINITION OF KEYWORDS

Conservation means the processes through which material, design and integrity of the temple is safeguarded in terms of its archaeological and architectural value, its historic significance and its cultural or intangible associations. It includes all the processes of looking after a place so as to retain its cultural significance

Intervention means the action undertaken with the objective of conservation, for the safeguarding of a temple and its integrity.

Maintenance means the continuous protective care of a place, and its setting. Maintenance is to be distinguished from repair which involves restoration or reconstruction.

Preservation means maintaining a place in its existing state and retarding deterioration.

Repair means removing or replacing decayed or damaged material or portion of a heritage site in order to impart stability and to prevent loss of original material.

Restoration means returning a place to a known earlier state by removing accretions or by reassembling existing elements without the introduction of new material.

Reconstruction means and includes returning a place as nearly as possible to a known earlier state and distinguished by the introduction of materials (new or old) into the fabric. This shall not include either recreation or conjectural reconstruction.

Retrofitting means to consolidate a heritage site’s structure by inserting new parts or new material / technology in order to improve their safety and to make them functional, implying structural strengthening.

Stabilization* or *Consolidation means action to arrest of processes of decay using external agents that are “time tested and proven scientifically”.

Authenticity is a value / significance imparted to a heritage site through a truthful and accurate depiction of one or more of the following elements:

- location and setting;
- form and design;
- materials, construction techniques and building craftsmanship; and
- function and traditional management systems

Integrity is the quality/ extent of the completeness / intactness of the heritage structure demonstrated through its attributes such as structural, functional (in case of a living heritage) and visual.

Sthapathi is a traditional, master craftsperson, with formal education or experience in temple architecture, recognized by the HR&CE. The traditional craftsmen have specialized knowledge in different aspects of temple construction namely Kal stapathi, is a craftsperson who is an expert in working with stone constructions and sculptures, Mara Stapathi , is craftsperson who is an expert in working with wooden structures.

Living Heritage/ Living Monument may be seen as a heritage site that maintains its original function, as continually reflected in the process of its spatial definition and arrangement, in response to the changing circumstances in society at local, national and international level.

Classical Texts include religious scriptures such as agamas and the traditional cannons of architecture such as the shipa shastra and vastu shastra.

Tangible Heritage: The UNESCO defines tangible heritage as built forms that include buildings and historic places, monuments, artifacts, etc., which are considered worthy of preservation for the future. These include the temple structures, the artifacts associated with it such as the temple car (chariot), stone and bronze sculptures, jewellery etc.

Intangible Cultural Heritage is explained as the cultural heritage that does not end at monuments and collections of objects. It includes traditions or living expressions inherited from our ancestors and passed on to our descendants, such as oral traditions, performing arts, social practices, rituals, festive events, knowledge and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts. Orienting this definition to the context of temples in South India, the intangible heritage has multiple dimensions. While the ancient, classical texts such as the agamas and shastras form an imperative part of the intangible cultural heritage as the traditional knowledge system governing the temple structures, there are also several traditional and social practices inherited over centuries, whose importance cannot be undermined. Practices such as annual festivals and celebrations at the temple, though may not be part of the classical texts, are cultural traditions that have been in practice for over centuries also form part of the intangible cultural heritage.

CONTENTS

CONCEPT OF CONSERVATION IN TEMPLES: 10

A1. Role of the Department:.. 10

A2. Need for Conservation:.. 11

A3. Classical theory for Renovation: Concept of Jeernodharana........... 12

B.1 Temple Architecture...15

B.1.2 Symbolic attribution to the temple structure:................................. 17

B.2 TRADITIONAL TEMPLE BUILDING PRACTICES: 20

B.2.1 Inspection of the site (Bhoo-Pariksha):.. 20

B.2.2 Selection of Building Materials:.. 20

B 2.3 Brick work:.. 21

B.2.4 System of Measurements:... 22

B.2.5 Layout and design of the temple: Ayadi Calculations 22

B.2.5 Foundation:.. 24

B.2.6 Aesthetic treatment: Varna Sanskaram 25

B.2.7 Types of temples built in South India.. 26

B.2.8 Different Kinds of Icons to be Enshrined in temples 27

B.3 CLASSICAL TEXTS ON TEMPLE CONSTRUCTION : 28

1.3.1 Introduction.. 28

B.3.2 Silpasastra: 29

B.3.3 The Agama Shastra: 30

B.3.4 SAMPROKSHANAM /KUMBABHISHEKAM................................ 32

B.3.5 Creation of Balalayam: balalaya stapanam.................................. 33

B.3.6 Occasion for creation of Balalayam: 34

B.4 JEERNORDHARANA OF TEMPLES 35

B.4.1 Factors warranting Jeernodharana:.. 35

B.4.1 Rules For Renovation/Re-Building Work According To Agamic Texts: 35

B.4.2 Repair/Reconstruction of Main Idol:... 36

B.5 ELEMENTS OF THE TEMPLE:...37

B.6 STRUCTURAL SYSTEM OF THE TEMPLES 43

B.7 ARCHITECTURAL FORMS IN TEMPLES 49
C Factors causing deterioration of historic structures 58
C 1 Causes of Deterioration and Defects 58
C.1.1. Mechanical Agents: 58
C1.2Thermal Agents 59
C1.3 Chemical Agents 59
C1.4 Biological Agents 59
C1.5 Earth Movement 60
C.2 Weathering of Stone Heritage Structures in India...............60
C 2.1 Mechanisms of Stone Decay 61
C 3 Historic Masonry Deterioration Problems.............................63
C3.1 Chipping 63
C 3.2 Cracking 64
C 3.4 Crumbling 64
C 3.5 Delamination.. 65
C 3.6 Detachment 66
C 3.7 Weathering 66
C 3.8 Efflorescence 67

CONCEPT OF CONSERVATION IN TEMPLES:

A1. Role of the Department:

The Hindu Religious and Charitable Endowments Department deals with the maintenance and repair work associated with the temples, in public use in Tamil Nadu. The duties of the department are detailed in the provisions of the Tamil Nadu Hindu Charitable Endowments Act, 1959, and the rules appended hitherto. The tender transparency Act is also applied for transparency in the activities of the public religious institutions. The foremost interest of the department is to maintain the religiosity and continuous functioning of the temples and ease of access and safety of the devotees. The department has at its disposal engineers and sthapathis and diverts funding towards the proposals for work on the temples when there are paucity of funds.

There are 38,615 Hindu Religious and Jain Institutions under the control of the Hindu Religious and Charitable Endowments Department (HR&CE Policy Note 2015-16). Among these around 8450 temples are over 100 years old.

A2. Concept of Thirupani

Thirupani can be any service rendered for the benefit and up keeping of the temples. It need not necessarily involve renovation or addition of new structures.

Some of the important considerations while doing any Thirupani work are a) working in accordance with the Agamas b) Preserving the resources: not only includes preserving the rich art and architecture of the Hindu temples, but also the valuable historical information available through murals, inscriptions, etc. c) Working in accordance with the local tradition of the temple, sustaining festivals, celebrations that are followed in the temple. d) maintaining the temples by periodic cleaning and removal of distresses e) maintaining the sanctity of the temples.

A3. Need for Conservation:

The temples under the HR&CE are ''living monuments' and are part of a continuing tradition. A living heritage structure may be seen as a heritage site that maintains its original function and has been an inseparable part of the cultural and spiritual activities. These structures have been in use for over centuries and are part of a living heritage. The classical approach to conservation applied to archaeological sites may not always work in concurrence to the situation in these temples.

Several temples of high historic value, that is in active use come under the administrative ambit of the HR&CE Department. While the archaeological interest in temple lies in the immediate preservation and conservation of the temple structures so as to showcase the rich architectural heritage as an object of national or international importance, the religious interest in temples deals with satisfying the sophisticated interest of the spiritual and informed sector of people directly involved with the temples. There are certain advantages to both the approaches and some form of mediation between the two approaches can be advantageous to built heritage. Temples being in active use have, as their prime purpose, the witness of faith for which they were built. Therefore, nothing must be done which would prevent this purpose from being carried out[1]. This heritage conservation manual aims at being a guideline for important conservation and maintenance works in the temples at the same time preserve the religiosity of the heritage sites.

The concept of conservation and protecting old structures is not new to these temple structures. *Jeernodharana* or renovating existing structures was practiced for a long time. Even today, repair and restoration of temples which are in use continues, but there is a difference between conservation as it is practiced by the Archaeological Survey of India and in other places. The discipline of conservation has as its fundamental objective the preservation of the physical heritage of the past from loss and depletion in the present. Here the main consideration is the protection and preservation of the physical, material structure. Such an approach to heritage management can embrace the rules and practices set by traditional knowledge systems only to a limited extent. In the traditional understanding, temple renovation

is considered as an ongoing process and aims at embracing change. Although the fabric is generally preserved, there are a whole range of traditional practices and rituals in which the physical or material structure is given secondary-priority.

The preservation of the fabric should be undertaken with a scientific and engineered approach. Therefore the manual attempts a confluence of good practices of conservation engineering and the presentation of traditional practices that are part of the intangible cultural heritage.

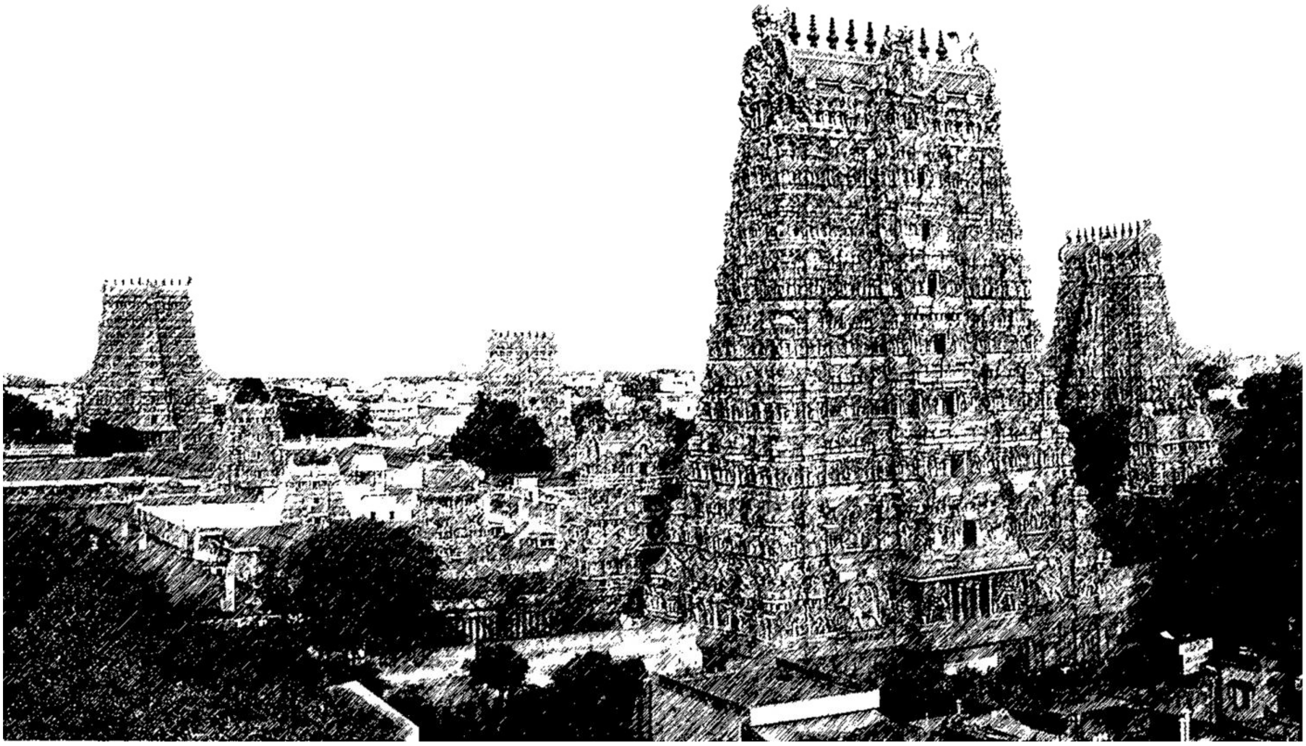
A4. Classical theory for Renovation: Concept of Jeernodharana

The building maintenance is explained by an analogous theory that the building is to be compared to a man. This analogous model of *Bhavanapurusa*, is attributed with the four stages of life, viz. childhood (balyam), adolescence (koumaram), youth (youvanam) and old age (vrudhakyam) It is now well known that the first three stages normally covered only one fourth of the full life of a man, and it is hypothesized that old age sets in gradually debilitating the human body with gradual loss of faculties. A new dimension was added to this life cycle by evolving an approach of renovation; *Jeernodharana* whereby the *Bhavanapurusa* practically takes a rebirth in physical and metaphysical sense. Interestingly, during the process of Jeernodharana in temples, it is believed that the original shrine is no longer functional, and *Balalayam*, a miniature temporary structure is erected. During this period, the divine presence of the main deity in the temple is transferred from the idol that is worshipped to a pot called *kumbam*, which is placedin the *Balalayam,* and the original shrine regains its vitality only after *the Kumbhabhishekam* , a renovation and purification ceremony and the main deity is brought back to the idol in the shrine. This process involves total physical renewal.

Hence, heritage management in the context of the living heritage structures under HR&CE moves towards a different context of understanding and safeguarding the temples. Where the conservation process must involve the consideration from several stake holders, such as the agama experts, silpa shastra

experts, as well as the local community, in addition to the conservation experts from various institutions.

INTRODUCTION TO TEMPLE ARCHITECTURE



B.1 Temple Architecture

Traditional temple building is governed by various physical and metaphysical systems. The physical paradigms like proportioning systems, yoni calculations form the basis of the layout and guide the elevation. In most temples, the design and proportions are based on classical texts including shastras and aagamas.

The temple is the house for the God or Goddess. The Vastu texts present the temple plan as homological to a human body. The human body serves as the plan for all creation. The temple structure is homologous to the standing purusa as the śilpa-pañjara. At a lower level, a similar measure informs the proportions of the sculpted form, that may be standing or seated, and also of painted figures[2].

The layout of the temple or a residential building is synonymous with the layout of the cosmos. The layout is a grid of 8 x 8 (64 spaces) or 9 x 9 (81 spaces) called Mandala . This geometry forms the basis of the replication of the subtle substance of the universe into visual material form, two dimensionally, as a square and three-dimensionally, as a cube. This cube with a square base is called Vaastu Purusha Mandala.

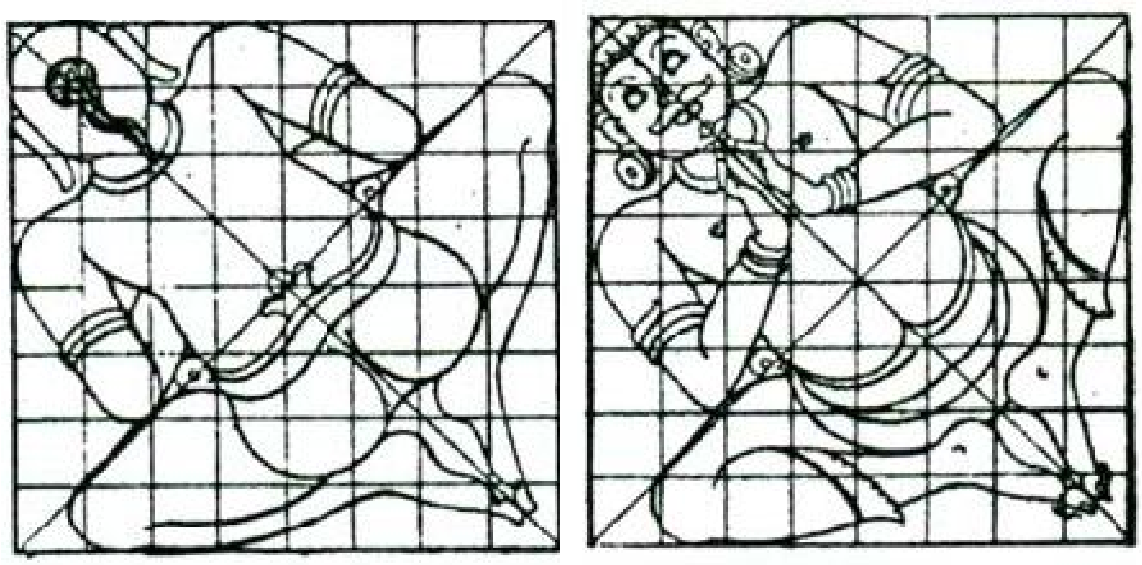


Figure 1 The Vaastu Purusha Mandala

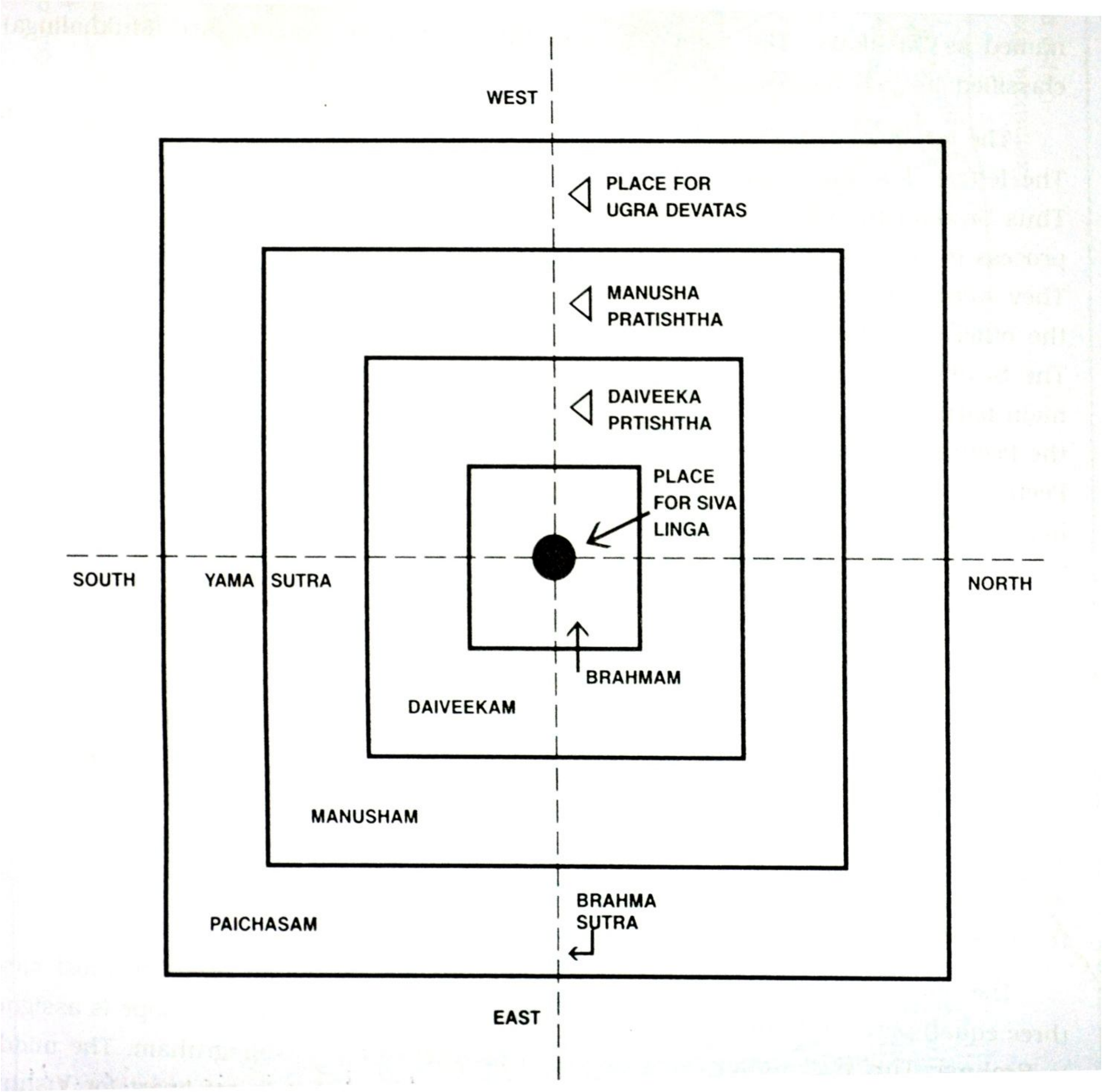


Figure 2 Placement of different kinds of Vigrahas facing east in the Garba Griha

Architecturally, this unit translates into the sanctum (garbhagriha), the womb chamber of the temple. Around the central square in the Vastu-Purusha Mandala are placed the 12 Adityas and on the borders are 32 Padadevatas, the deities representing celestial bodies[3].

The physical orientations of the temple are invariably established in relation to the motion of the planets. The four sides of the square lies towards the cardinal

points and the corners towards the intermediate points of the compass. The temple is correctly located in both space and time..

According to texts, especially the Brhat Samhita, the Vastu-Purusha Mandala of 81 squares (9 x 9) and 64 squares (8 x 8) is further divided into smaller units[4]. An elaborate correspondence is established between each of these squares and the planet deities. While Brahma occupies the central square and is always the presiding deity coinciding with the navel, the central axis mundi, the sanctum, the garbhagriha, other deities occupy adjoining squares. In the outer series, there are deities like Indra, Jayant, etc., and in the outermost are the various minor deities including also the asuras (demons).

B.1.2 Symbolic attribution to the temple structure:

The analogy to the human body is extended to explain the various parts of the body as being representations of the aspects of a temple. In this process, the forehead is said to represent the sanctum; and the top of the head, the tower. The space between the eyebrows, the ajna chakra, is the seat of the divinity. The finial of the tower is the unseen the sahasrara located above the head.

The ornamental plinth of the temple represents the holy feet of the God and the stool supporting them; The thighs and knees are represented by the Adhishthanam; Torso with the hands of the God is represented by the walls covering the Sanctum Sanctorum (Padavargam); The bold ornament resembling the Purna Kumbham, embedded in the Padavargam symbolise the stomach and navel; The cornice capping the Padavargam represents the shoulders; The kandam (below the Shikara) symbolises the neck; The Shikara represents the face and top of the head of the God; The Buddhist Sun window on the Shikara represents the nose, and the eyes are represented by lotus-like ornaments on either sides of the windows[5].

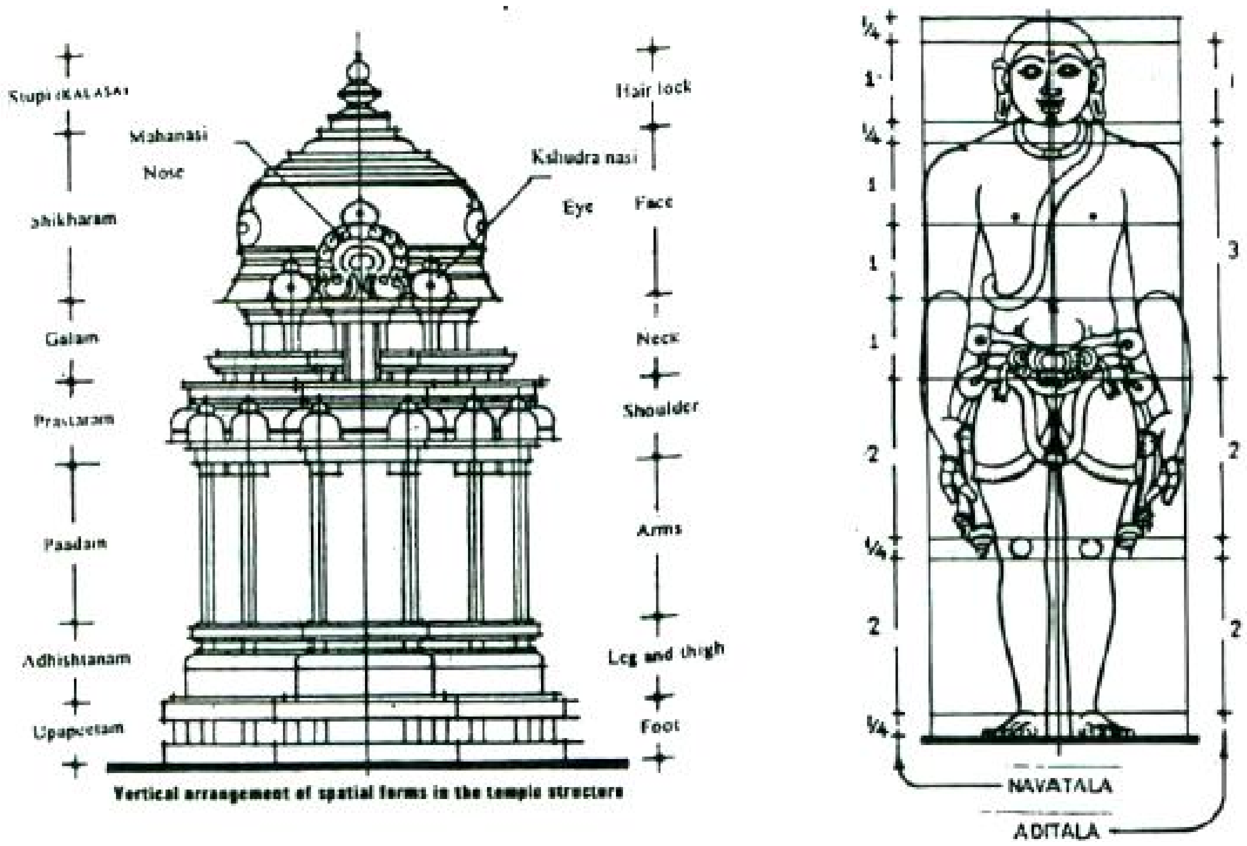


Figure 3 Vertical arrangement of spatial forms in the temple and its relation to the human form

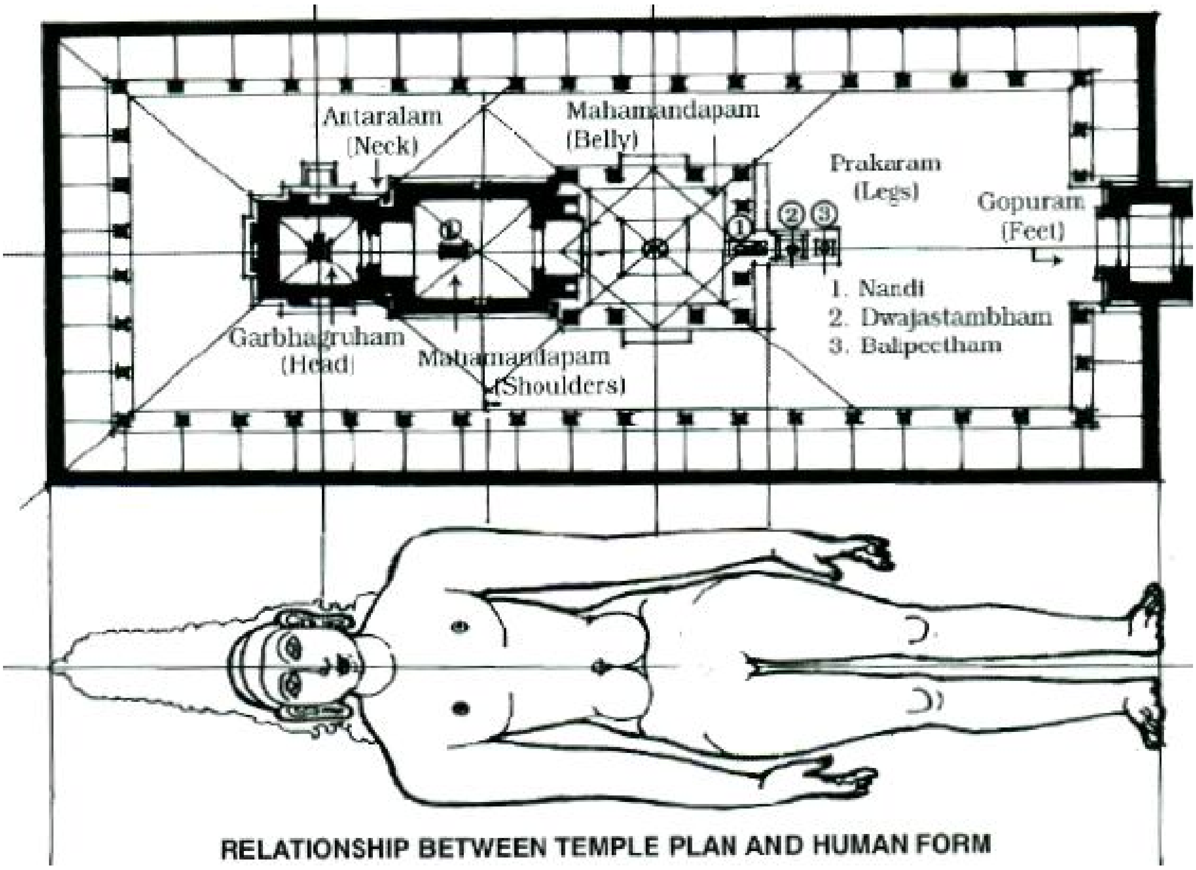


Figure 4 The temple and its relation to the human form in plan

In the plan form, the symbolic attribution extends to the various architectural forms in the temple. The Raja Gopuram is the feet of the Body. The devotees enter the Temple from the feet, proceed through the prakaram, which form the legs, and move to the Mahamandapam, the belly and the antralam, the neck and to finally reach the Garbhagriha which is the Head of the Body.

B.2 TRADITIONAL TEMPLE BUILDING PRACTICES:

B.2.1 Inspection of the site (Bhoo-Pariksha):

After the inspection of the site for its consistency it is important to check the condition of the soil. This can be determined by performing some simple test on the site. These tests are described in the Shilpa Shastras as well as the Agamas.

Firstly, a pit of 2'9" (1 muzham) length by 2'9" (1 muzham) width is dug on the site. And after performing the religious rites the pit is filled with water and the water is allowed to seep in overnight[6]. By morning the pit is inspected, and if there is some water remaining in the pit, or the soil is damp the site can be considered for construction. If the soil appears dry, it is considered unsuitable for construction (akin to measuring the permeability of the soil).

The soil which has been taken out is put back again and checked whether the level of the packed soil is higher, same or lower. The land with the higher is the most suitable for temple construction (akin to measuring or estimating swell index).

Finally, the fertility of the soil is tested by sowing a seed at the chosen site on a auspicious day and the germination is observed. If the growth of the plant is noticed in 3 days the site is most suitable; if in 4 days, it can still be considered, in case of 5 days or more the land is not suitable for the construction of the temple.

After all these preliminary investigations, the selected site needs to be leveled: the ground where the temple is to be constructed should be throughout an equal plane. When the inspections, leveling and tilling is done, the site is ready for the laying out the divine diagram or the vastu-purasha mandala.

B.2.2 Selection of Building Materials:

The building materials that are prominently used in temple construction are the stone, the bricks and timber. Temples can be entirely made of stone from foundation to the superstructure (*Purusha Vimana*), the entire structure is

stone and the superstructure may be built with brick and lime mortar (*Sthree Vimana)*, or the superstructure may be built with a combination of stone, brick and wood (*Napumsaka Vimana*).

The building materials such as stone and brick also have similar classification. Purusha kal (male stones) are stones that are big and rounded, they produce sparks when stuck with a chisel, and they are strong and suitable for construction of columns. Shree kal (female stones) are medium in size, soft to touch with a broad base, suitable for beams and Napumsaka kal (Neutral stones) are smaller, not sounding and are suitable for aggregates.

The size of the structure will also determine the various kinds of building materials to be used at different stages of the construction. They also help to control the proportions of the dimensions of the temple. These norms carry shades of religious intentions too; the set of six formulae or Ayadivarga viz., the Aaya, Vyaya, Yoni, Tithi, Vaara and Nakshatra are applied by the Stapathi to determine the proper orientation and dimensions of the structure.

B 2.3 Brick work:

The bricks were used in the temple structures mainly for erecting Gopuras, the temple towers and Vimanas, the domes over the sanctum.

As per the descriptions given in *Manasara* the bricks were made in various sizes; the size of the bricks varying from 7 inches to 26 or even to 31 inches in length. The length of the bricks were 1 ¼, 1 ½, 1 ¾ or 2 times the width .The height of the brick was ½ its width or equal to the width. Thus, bricks of different sizes, shapes, and types were made. The composition, shape and baking of a brick depended upon the use to which it was put[7].

The normal size of bricks of early historic period is 42 to 45 cm x 24 to 33 cm x 7 to 8 cm. The Pallava period bricks are of 28 x 13.5 x 6cm; 28 x 16 x 5 cm and 29 x 15 x 5 cm and the Chola period bricks are of 21 x 12 x 5 cm; 24 x 12 x 5 cm and 27 x 17 x 7cm[8].

Interestingly, the bricks with straight and linear edges were called male bricks; while those with a broad front side and a narrower back side or those of curved shape were called female bricks. The bricks in concave shape were called neuter bricks. The male bricks could be used in the construction of the ***prasada***, the sanctum. The female bricks were used for the sanctum of female deities. The neuter bricks were generally not used in temple construction; but were used for lining the walls of the well.

According to Sh*ulba Sutra*, bricks measuring 22.8X11.4X5.7 cms were used in construction of walls.

B.2.4 System of Measurements:

Table of Space Units

8 Anu (atom)	**1 Drasarenu**
8 Drasarenu (car dust)	**1 Kochakram**
8 Kochakram (size of nits)	**1 Paen**
8 Paen (size of lice)	**1 Nel**
8 Nel(grain of rice)	**1 Angulam**
6 Angulam	**1 Talam**
12 Angulam	**1 Vitasi**
24 Angulam	**1 Kishku Muzham/Hastham**
8 Hastham	**1 Dandam**
8 Dandam	**1 Rajju**

Table 1.1Traditional System of Measurements

The shilpis of Tamil Nadu use a scale of 24 angulas that is equal to 33 inches or 2'9". One manangula measures 13/8" and 24 such manangulas make one kishku hasta,2'9". Managulam units are used in sculptural and finer details, while the layout and elevation of the temple is measured in Hastham.

B.2.5 Layout and design of the temple: Ayadi Calculations

Hindu temple construction is strictly based on a complex system of measurements and proportions. These proportions control every aspect of a temple's design, from its width and height to the size of its doorways and moldings.

Ayadi is a technological application for building design and construction. 'Aya' means 'length' and 'adi' means 'source' or 'moolam' as in the name of 'moola shakthi'- source of power'. There are six aspects to be examined under the ayadi, namely 'aya'- benefits, Vyaya-expenditure, Yoni- direction indicating the flow of energy, vara- week, Naakshatra-star, Amsa-quality. All these aspects are established and are included in the calculation of the dimensions of the temple.

The rules of Vastu-shastra render beauty, structural stability and quality of spaces by virtue of light, sound and volume management. They also evoke in the devotee an attuning of his person to its structure and ambience. As regards the volumes, every part of the temple is rigorously controlled by a precise proportional system of interrelated measurements, maintaining the fundamental unity of the architecture and sculpture.

The Vastu Purusha Mandala of the temple projects the temple in two main sections: the ground plan and the vertical alignment. The patterns drawn in the Mandala relate to the horizontal section or the ground plan. The subdivisions of the ground plan detail the Brahmasthana (the main shrine and smaller shrines) and the Mandapas (pavilions). The vertical alignment consisting the pyramid, the circle and the curve are meant for designing the Gopura (entrance ways), the Vimana (the structure above the main shrine) and the prakara (the walls).

The number of prakaram or enclosures can vary from 1 to 5 and the number of tiers or nilai for the superstructure can vary from 1 to 16. There is a direct relationship between the size of the openings, the size of the prakaram/enclosures and the height of the raja gopuram. In Srirangam, while there are seven enclosures, the outer two do not constitute the temple.

The width of the opening in the prakaram walls is in proportion to the width of the opening in the garba-griha wall. And this entrance opening increases with the

increasing number of prakara walls. And correspondingly the height of the Raja Gopuam also increases. Hence, we find higher Raja Gopuram, in places with several enclosures such as Srirangam, Ranganathaswamy temple, Madurai Meenakshi Sundareswarar temple, etc..

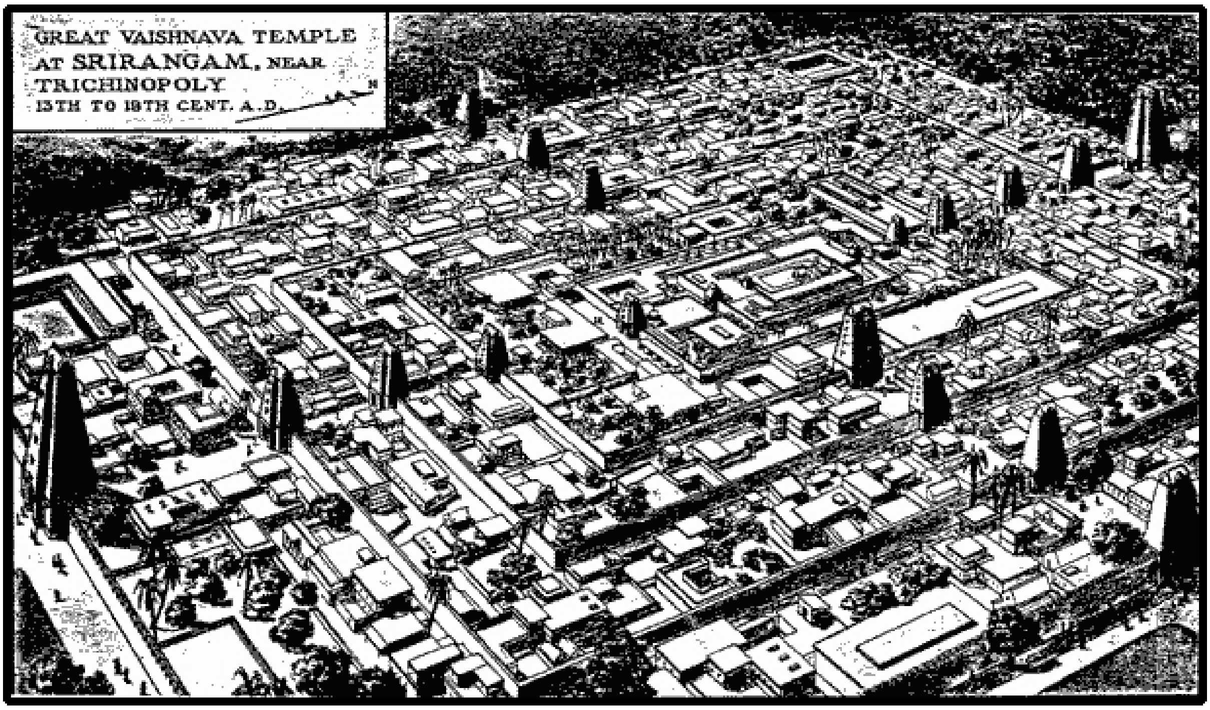


Figure 5 Succession of Rajagopuram in Ranganathaswamy temple, Srirangam

B.2.5 Foundation:

The selected site is leveled, and a trench for the foundation is dug till the water table level or till the rock bed level or till the level of fine sand is found under the ground. This trench is filled with layers of stone of varying sizes, sand is poured in to fill the gaps between the stones and a lime mortar mixture is poured after each layer. The lowermost part is filled with stones, the size of elephant heads, followed by stones, the size of coconuts, followed by stones, the size of monkey heads. Over this alternate layers of dressed, coursed stones are laid length wise and breadth-wise and the plinth is constructed on this course[9].

B.2.6 Aesthetic treatment: Varna Sanskaram

Originally white, off-white or sandal shades in lime water were used for the terracotta sculptures of the gopurams. In the case of *panchavarnam* the five colours were taken from naturally occurring colours and applied in a thin coat. This gave the delicate sculptures a bright and lasting appearance.

The purpose of applying colours is not only to enhance the aesthetic appearance but also to improve the durability of the surface.

White, yellow, red, black and blue are five basic (pure) colors. All other composite colors are made from these colors.

White color - White color is prepared from lime made of shells or mother of pearls or from white clay (pottery clay-Kaolin). White color is prepared by mixing resins of Neem or wood apple tree with white soil or lime. The mixture is pulverized and dissolved in hot water.

Yellow color - Yellow color is prepared from pounding yellow wood trees (Haridra) and yellow soil (from hills or river banks) together. The mixture is poured in clear water for two hours. The top yellow solution is stored in earth pot till it dries. The dry powder is used for preparing yellow color.

Red color - Red color is prepared from Sindur (Vermilion), Gaierik (Red ochre), Hingul (Cinnabar) or Laksharus (Shellac) to get light, medium, dark and very dark shades respectively. Red ochre is finely pulverized and sieved through a muslin cloth. The powder is cleaned by mixing with water. Vermillion is mixed in water and stirred for 12 hours..

Black color -Oil lamp is ignited in a mud pot. Inner surface of another mud pot is smeared with powder of dry cow dung. This pot is place on the first pot such that lamp black is coated inside the top pot. The lamp black is cleaned with water before application.

Blue color - Blue color is prepared by drying a mixture of blue minerals or indigo and resin of wood apple.

Golden color - Golden color is prepared from gold foil pulverized with fine sand. The mixture is poured in water and top suspension is separated and mixed with adamantine glue. The painted surface is polished with horn (of an ox or swine).

(Source: Vishnudharmottara Purana , Chitrasutra , Abhilishartha chintamani)[10]

B.2.7 Types of temples built in South India[11]

(in the early historic period according to early pallava rulers before 7th century

1. ***Perunkoil or Madakkoil:*** Literally, it means a big temple, this category of temples were built either on natural or man-made mounds. The ones built on the high platforms or pedestals known as Maha Peetha were known as Madakoil. The ancient Tamil literature refers to Brihadeeswara temple at Tanjore as, Madakkoil. The temple at Tirunalloor located on top of a hill is known as Perunkoil.
2. ***Karak koil:*** these types of temples were fashioned after the temple chariots which were taken in procession in the streets located around the temple complexes during the annual festivals. The stone ratha (chariot) found in the temple at Melakadambur (near Chidambaram), and in the Shiva temple at Darasuram are examples of this type of shrine.
3. ***Gnazhar koil:*** An ancient inscription from Tamil Nadu refers to Lord enshrined in the well-known temple at Kadalur (Thiruppadiripuliur) as Tirukkadai Gnazhar Peruman. According to some scholars, the place of worship of the images of gods installed in the shade of Gnazar tree which belong to the category of big trees viz. Kondai, Kongu, Thekku (teak), may be included in this type of temples. The temples which were built with posts, beams and rafters made out of wood obtained from the Gnazhar tree may also be categorized under this type.
4. ***Kokkudi Koil:*** In ancient Tamil Nadu, a kind of rambling jasmine shrub was known as Kokkudi. Perhaps, temples which were surrounded by the gardens, where this shrub had been grown, were called as Kokkudi koil. Shiva temple in Talaijnayiru near Seerkazhi and Shiva temple at Tirumurugan poondi belonged to this category of kokkudi temple.

5. ***Ilang koil:*** The square pavilion which is open on all four sides and its roof supported by four corner columns is called as ilang koil. The tamil epic, Silapadhikaram mention that the icon of Lord Venkateshwara at Tirumala-Tirupati was installed in an ilang koil and worshipped by the shepherds who lived in the green valleys of the Tirumala hills. Even today, on the banks of the rivers and on the bunds of village tanks, small temples in the shape of open mandapams can be found in all parts of Tamil Nadu sheltering Shivalingas, images of Ganesha, or other village dieties. All these tyoes of small temples are classified as ilang koil.
6. ***Manik Koil:*** A temple which had been built with its Vimana (Superstructure) resembling a bell is categorized as manik koil. The Nataraja temple at Chidambaram and the monolithic Draupadi ratha at Mamallapuram are examples of Manik koil.
7. ***Alak koil:*** The place of worship without a structure, placed in the shade of a banian tree (Vata Vruksha) with its green foliage serving as its roof, is to be called as Alakkoil. The banyan tree is considered to be sacred by the Hindus. All over Tamil Nadu, open temples for the worship of deities such as Ganesha, Lord Shiva, Hanuman, Naga devatas and grama devatas (Village deities), are a common sight especially under the banyan tree or the Pipal tree grown on the bunds of village tanks.

B.2.8 Different Kinds of Icons to be Enshrined in temples

The need for building a temple would arise only when there is an icon or symbol of the deity like Shivalinga which is to be enshrined for worship. There are five kinds of icons (Murthis) which are being worshipped in the temples and they are as follows:

1. ***Swayambu:*** The icon or symbol which is believed to be the one which is self-manifested.
2. ***Daiveekam:*** The icon or symbol which is believed to be installed and worshipped by divine personage viz. Bhrama, Indra, Vayu, Varuna, etc
3. ***Arsham:*** The icon or symbol which has been installed and worshippped by renowned Rishis.

4. ***Manusham:*** The icon or symbol which has been installed for worship by the kings, philanthropists or devotees.
5. ***Asuram:*** The icon or symbol, according to Puranas, that had been installed and worshipped by the Asuras or demons.

According to the Agamic codes, the temples had been built at the very spot where it was believed that a particular deity had self-manifested, or on the spots which had been identified as the ones where the Devas, Rishis or Asuras installed the icons and worshipped them. These temples were called Puradhana koil, temples of high religious and historic significance.

B.3 CLASSICAL TEXTS ON TEMPLE CONSTRUCTION :

B.3.1 Introduction

The two bodies of knowledge that are the only authentic authority on temples and icons are the Agama Shastras and the Shilpa Shastras. These texts have been held and only fully understood by the Shilpis and Sthapatis (sculptors, architects, and builders) of ancient days.

Both Shastras state that God has a definite form in subtle as well as gross state, and they are both the same. These Shastras establish a science-based link between the image of God or Brahmam and the devotee.

Temple architecture is based upon ancient principles that were held closely by the ancient lineage of Vishwakarmans or Shilpis and Sthapatis. They establish that the term spiritual experience or bhakti to be a science based experience. God is only one, being the most scientific, energetic substance, full of consciousness, which in tune with itself turns into many forms known as self-manifestation. Absolute Space, which he sometimes called Vastu or Brahmam or Vastu Brahmam, is that only feature which is worthy of worship. The function and purpose of the giant vibrating Vaastu structures such as temples was to excite the Primal Fire within each human so that we could resonate perfectly with Cosmic energy[12].

Temples are considered the instruments housing and emanating of positive cosmic energy. The Upanishads say, "Look upon the temple building as embodied energy and worship Him with Vedic mantras."

Elaborate rules are laid out in the classical texts for Silpa (the art of sculpture) describing the quality requirements of the places where temples are to be built, the kind of images to be installed, the materials from which they are to be made, their dimensions, proportions, air circulation, lighting in the temple complex etc.

The Manasara and Shilpasara are some of the works dealing with these rules. The rituals followed in worship services each day at the temple also follow rules laid out in the Agamas. The Shipa Shatras describe the requirements of the temple site; building materials; dimensions, directions and orientations of the temple structures; the image and its specifications. The principal elements are Sthala (temple site);Teertha (Temple tank) and Murthy (the idol).

The *Manasara* mentions four guilds which were involved in production of things I) *Sthapathi* (architect) 2) *Sutragrahi* (in charge of measurements) 3) *Vardhaki* (in charge of strength and quality of materials) and 4) *Takshaka* (worker in wood, stone and metal)[13]

B.3.2 Silpasastra:

The Silpasastra provides a comprehensive framework for both sculpture and architecture. It describes the details formulating the varieties, provides the norms, suggests the methods and enjoins some rules to be followed. We have now references to more than four hundred texts on *Silpasastra.*

Brahatsamhita written by Varahmihira describes the sculpture and architecture and paintings. The text recommends a temple site of sixty-four squares.

Samarangana Sutradhara, dating back to 11th century A.D. mentioned craftsmen, artists and their fascination for their work by observing several factors like wisdom or traditional skill, study of texts, etc.

Mandana Sutradhtira belongs to 15 th century A.D. It prescribes 1) *Vastumandara* 2) *Prasadamandara* 3) *Rupamandara* which deal with iconography, sculpture and architecture respectively. In the field of sculpture nearly 400 documents were written.

Books like *Silapratna, Pratima Lakshana, Devatamurti-Lakshana* and *Sanat Kumar Silpa* deal with icons for worship in temples. Texts like *Chitra Karma- silpa, Saraswati-silpa, Silpa lekha* etc. are concerned with images for ,secular purposes. Texts like *Sileisangrah, Darusangraha, Dipika* and *Parshana vichara*etc., recommend the selection of wood or stone for icons. Books like *Pratishtha-tantra* and *Pratishtha-vidi* are popular for installation of icons[14].

One of the most important shilpa shastra texts when dealing with the constructions in South India is the Mayamatam. The mayamatam deals with the layout and construction of villages, towns and temples. The selection of suitable site for temples, the variety of pillars, types of mandapas and patterns of gopura are discussed.

Shilparatna is a classical text on traditional South Indian representational-performing arts. It is particularly influential in painting and theatrical performance. It lays down the tenets of painting such as the proper set of colours and the right combinations which leads to stylized balance and rhythm.

B.3.3 The Agama Shastra:

The Sanskrit word 'Agama' means a compendium of the codes of worship of divinity in general or a particular divine form. Rules for constructing temples and religious practices are laid down in classical texts called Agamas. Agamas deal with the philosophy and spiritual knowledge behind the worship of the deity, the mental discipline required for this worship, and the specifics of worship offered to the deity.

Agama Shastra plays a significant part in consecration and construction of Hindu spiritual abodes; a lot of Hindu places of worship follow the tenets of the Agama Shastra. Temples and places of adoration cannot be constructed arbitrarily

or based on some notion, for everything is laid down categorically in the Agama shastra. For example, for a religious pilgrimage the three essentials are Sthala, Tirtha and Murthy. Sthala refers to the abode of the temple, the Tirtha signifies the temple tank and Murthy refers to the idol. There are rules in the Agama Shastra for just about every aspect, including the minutest details, from the placements of holy idols to the components with which the temples are to be constructed.

There are several texts associated with different presiding deities. They can be broadly divided into three sets of Agamas: Vaishnava Agamas, worship God as Lord Vishnu; Shaiva Agamas, worship God as Lord Siva and Shakta Tantras , worship God as Mother Goddess. The two main schools in the Vaishnava Agama are Pancharatra and Vaikanasa Agama.

Kamikagama

The Kamika Agama, a principal Saiva Agama, is a primary source for details of personal worship, temple construction, dedication and worship and many aspects of home and village design. The kamika agama is one of the most elaborate agama, and most of the temples in south India follow this. It deals with all the rituals karshana (turning the sod), to prathista (installation of dieties), It describes about craftsmen who worked on wood, gold, iron, cane, stone, etc., It also described skill of the craftsmen while manufacturing their ware — how they used their hands, intelligence, etc., and how it was important for functional property and elegance[15].

Mukutagama

Mukutagama also reveals the different styles of Hindu temple *sikharas.* It gives a broad account of different features of *Nagara, Dravidian* and *Vesara* types (discussed in the following section) of temple *sikharas*[16].

Suprabhedagama

Suprabhedagama is quite specific on the boundary wall of the temples. It also gives a broad account of temple *prakara.* Types of *prakara,* towers, *gopura,* etc., of

prakaras have been described in it. It recommends that temple gateways should be in all four directions on the outer wall of the temple *(Chathurdwaram-Chathurdikshu)*[17].

Ajitagama

Ajitagama gives us a list of materials which is to be preferred for making icons like gems, stones, metals, wood and clay which are to be used according to order[18]. It also describes *Linga'* as pillar of light *(Jyoti Stambha)* etc. *'Brihat Samahita'* has given an account of *Vastu Mandala* in temple architecture

B.3.4 SAMPROKSHANAM /KUMBABHISHEKAM

Renovation and restoration of old temples was an important activity for the sthapati as well as a pious act for the patron or donor. The temples can be expanded and renovated and rededicated with an elaborate ceremony called the Maha Kumbhabhishekam.

During this period, the divine presence of the main deity in the temple is transferred from the idol that is worshipped to a pot called *kumbam*, which is in turn used in the creation of the Balalayam, and the original shrine regains its vitality only after *the Kumbhabhishekam*, a renovation and purification ceremony and the main deity is brought back to the idol in the shrine.

In the traditional perspective, the objective of maintenance work is to establish the continuing spiritual presence of the presiding deity within the temple. For this, a ceremony of re-dedication of the temple is done once in 12 years or whenever there is a physical distress to the temple structure, especially to the garba-griha, its vimana or the idol of the main deity.

According to aagama shastras, Samprokshnam, the dedication of the temple to the God happens in the following instances. Temple and Vigraha Prathistai installations are of three types.

(i) Avartam:

This is done for newly constructed temples

(ii) Anavartam:

This is the Samprokshanam done after the temple washed away from flood, affected by fire or other calamities. The re-dedication of the temple is done along with renovation work, often a Maha kumbabishekam is not necessary for minor damages and repairs, rather a lagu(small) samprokshanam may be done.

(iii) Punaravartham:

Jeernodharana Ashta Bandhana Maha Samprokshanam (Re-consecration after renovation) A complete renovation work is carried out. and a maha-kumbabishekam is done by constructing a balalayam.

(iv) Andaritham: Renovation work undertaken in case of vandalism of the temples by thieves or adversaries.

During Kumbabishekam period, Balayalam is done in a Hindu Temple. To be precise, the divine powers of the main Deity along with other Deities of the Temple are transferred to a Kalasha. The Kalasha is placed in the Balalayam. This is specifically done during the renovation period of a temple. Since the divine presence of the Main Deities are transferred to the holy waters contained in the Kalasha, puja is done to the Kalashas and Ustava Vigrahams of the Temple. During this period, no puja will be performed to the Moola Vigrahams (main idol). The divine presence of the temple deity will continue to be in the Kalashas only until it is transferred back to the Moola vigrahas, on the day of Kumbabishekam.

B.3.5 Creation of Balalayam: balalaya stapanam

Can be in the form of

1. kumbam vigraham: the sannidhyam/divine presence is transferred to a pot of water. The kumbams will be installed in the yagasala for one to three days and on the day of the maha kumbabishekam, the idols after they are well placed with ashta bandhanam, will be anointed with holy water of the respective kumbams. This is the

general practice. It is believed the presence of God in the Kumbam, must be only for a short period of time, up to one month.

2. Kathi vigraham: the sannidhyam/divine presence is transferred to metal objects such as swords or knives. This is commonly practices in Kula deivam temples, (temples with vernacular folk traditions). This balalayam can function up to 2 months after which it has to be renewed performing the rites again to summon the devine presence back.

3.Koorcham vigraham: The sannidhyam of the idols are transferred to pictures specially drawn for the purpose or in a mirror. This form can function for up to 2 to 3 months.

4.Daru Vigraham: For Balalayam Athi (ficus glomerata) wood can be used to transfer the sannidhyam from the primary idol. This balalayam can endure up to one year. After which the kumbabishekam must be done or the renewal of the balalayam is done.

5.Chithiram vigraham: In some cases a drawing/Chithiram of the presiding deity is made on a plank of wood from the Athi tree, in place of a Athi Vigraham

B.3.6 Occasion for creation of Balalayam:

The balalayam is erected during the Kumbabishekam period, when the temple is renovated and re-dedicated in a grand ceremony. Besides this, whenever there is renovation work done in the temple, anavarthanam, purnavarthanam,or anatharidham a balalayam may be constructed.

It is suggested that the balalayam, be constructed and the divine presence transferred only when there is any renovation work done on the main idol, in the garba-griha or in the Vimana. Renovation work in the compound walls, mandapas, etc can continue without the creation of balalayam. In some cases the renovation work may be carried out even within the garba-griha, for example the flooring of garba-griha, without the creation of a balalayam. For this, a wooden box is erected

around the main idol and work is done around it. An unnecessary or long period of transfer of the divine presence is not desirable.

B.4 JEERNORDHARANA OF TEMPLES

The importance attached to this process of renovation and maintenance in the classical understanding is even more evident in the concept of *Jeernodharana* of the idols and structures in the temple premises. Rules for Jeernodharana layed out in the agamic texts provide information about the handling and treatment of derelict structures that are beyond religious use, in order to bring them back to active religious use.. Several Agamic texts highlight the importance of jeernodharana of the temple to ensure the well-being of the state and its people. The texts give a detailed outline on the factors warranting the need for complete Jeernodharana (Renovation or replacement of the idols and structures).

B.4.1 Factors warranting Jeernodharana[19]:

as mentioned in *THRAYODASA: 13TH part, Atha Skanthothsva Vidhi, (in Kumara Thandiram, published by Thandayuthapani thirukoil, Palani: 2003))*

- cyclone, fire, and action by waves and floods as the important natural forms of disasters
- Damages to the main idol due to theft, attack by animals, fire, etc are imporatnt factors to be considered for the Jeernordharana of the Idols.
- Damaging action by waves and floods to the main idol calls for re-building of the temple structure at a specific distance away from its existing location.

B.4.1 Rules For Renovation/Re-Building Work According To Agamic Texts:

According to Jeernordharana Vidhi, the proper replacement of materials must be done to ensure well-being of the temple and its people.

Metals such as Gold, Silver, etc, must be replaced with metals of the same of higher value. The texts mention the importance of rebuilding in the same scheme, with the similar materials and similar sculptural program.

The emphasis in classical texts is on renovation of buildings damaged by natural disasters or the relocation of buildings submerged or destroyed by erosion under sea waves, floods etc.

They also explicitly state that the replacement or renovation of a derelict structure must be carried out using materials and techniques, to restore it to its previous form. This approach is important in the present day principles of conservation as well.

The texts prescribe that the renovated structures shall have the same prime dimensions and materials as those of the original buildings. The prime dimensions of monuments are reckoned as perimeter or lateral dimension. In the case of a temple for example, the width as measured at paduka, jagati or uttara was referred to as the danda, the reference module. All elements of horizontal composition starting from the cella (garbhagrha) to the outermost boundary (prakara) were proportioned from this module. Hence, from the most fragmentary evidence it was possible to work out the entire reconstruction work. The Sthapatis knew this horizontal rhythm (talachanda). The plan also decided the vertical composition (urdwachanda) and the dimension of elements in that. The knowledge of materials and their assembly was zealously guarded by the hereditary silpins. Hence renovation work was almost a repetition of original construction.

B.4.2 Repair/Reconstruction of Main Idol:

In case of any damage to the main idol, it must be noted whether the damage is in the maha-anga (head, chest, torso, abdomen regions), anga/upanga (hands, feet, fingers), or prathyanga (weapons, vehicles, pedestals, props). In case of damage to the maha-anga, it is considered as the passing away of the divine presence and the idol is discarded. The discarded idol is immersed in water (Visarjan) in the ocean, water bodies or wells. In case of damage to the anga or prathyanga, repair and reconstruction may be done according to the classical texts and consultation with the Stapathi and agama expert.

Uloga Binbam, idols made of alloys, panchalogam or bronze or gold idols, can be repaired or reconstructed using a similar metal or a metal of higher value. As much as possible the old metal may be used. The damaged idol can be buried underground for a specified period of time and religious rites are performed over it. And the same idol can be unearthed, re-melted and used to make a new idol.

In case of discarded wooded idols, the agamic texts prescribe that they be buried in the West of North direction of the temple complex.

B.5 ELEMENTS OF THE TEMPLE:

A typical temple in Tamil Nadu has fairly well-defined features and a generally accepted layout. The most important structure of a temple is the garbhagriha or sanctum sanctorum which houses the idol of the presiding deity.

The Garbagriha is followed by the mandapas or pavilions. Mandapa means any roofed, open or enclosed pavilion (hall) resting on pillars, standing independently or connected to the sanctum of the temple.

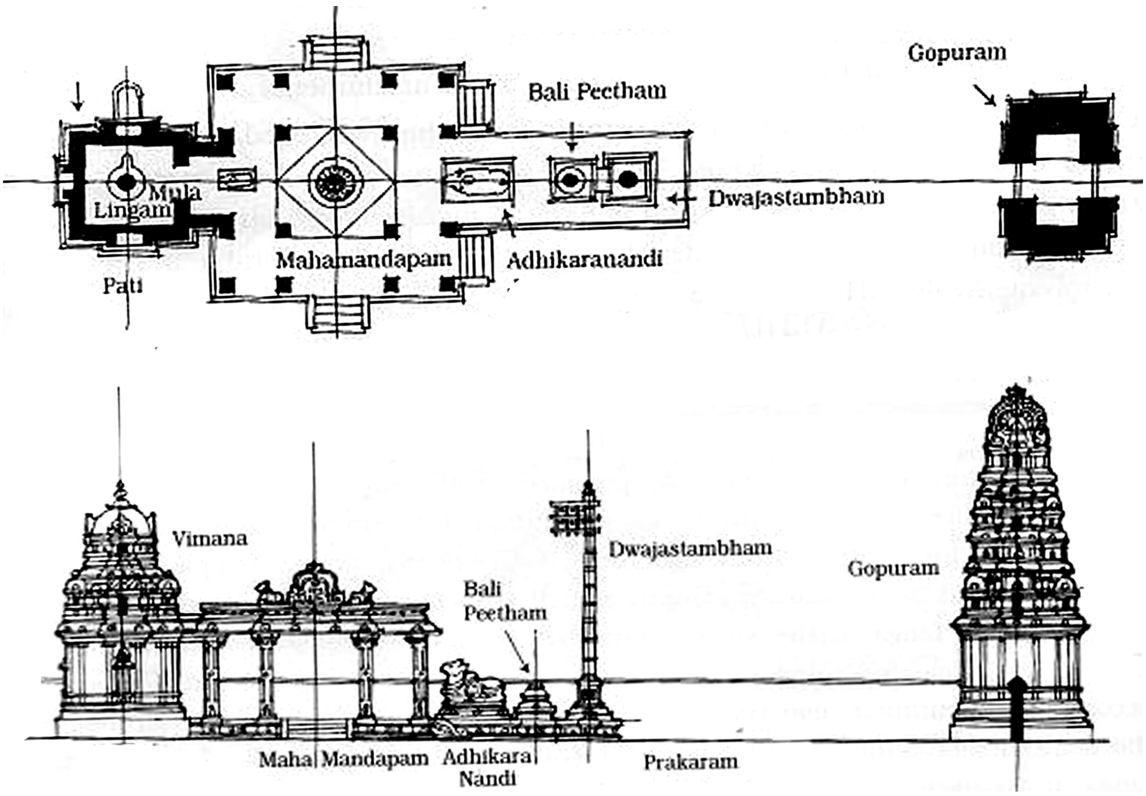


Figure 5 Elements of the temple

The sanctum or garba-griha:

The most important part of a temple is the garbhagrha or the sanctum sanctorum, the inner most chamber located within the Brahmasthana of the Vastu Purusha Mandala, where the idol of the presiding deity is installed.

According to the nature and placement of the presiding deity, the entrance will be determined either to North or to East of Garbagriha. The placement of other deities will also be determined accordingly.

Garbhagriha usually is a cube with a low roof and with no doors or windows except for the front opening. The image of the deity is stationed in the geometrical centre, facing the midpoint of the chosen direction. The sculpture and carvings at the doors and the vicinity of the Garbagriha are modest and not so exuberant as to distract the attention of the devotee. In some temples, a pradaksinapatha (a circumambulatory passage) is provided just round the garbhagrha, to enable the devotees to go round the deity.

Vimana

Often, Vimana means the tower shikara, raised to its final height above the sanctum. The southern texts describe the temples as sadvarga Devalaya. The sadvargas of a Vimana are Adistana, Pada, Prastara, Kanta, Sikhara and stupi. The vertical expansion of the sadvarga developed into Vimanas of Dvitala (in two stages) and tritala (in three stages) structures[20].

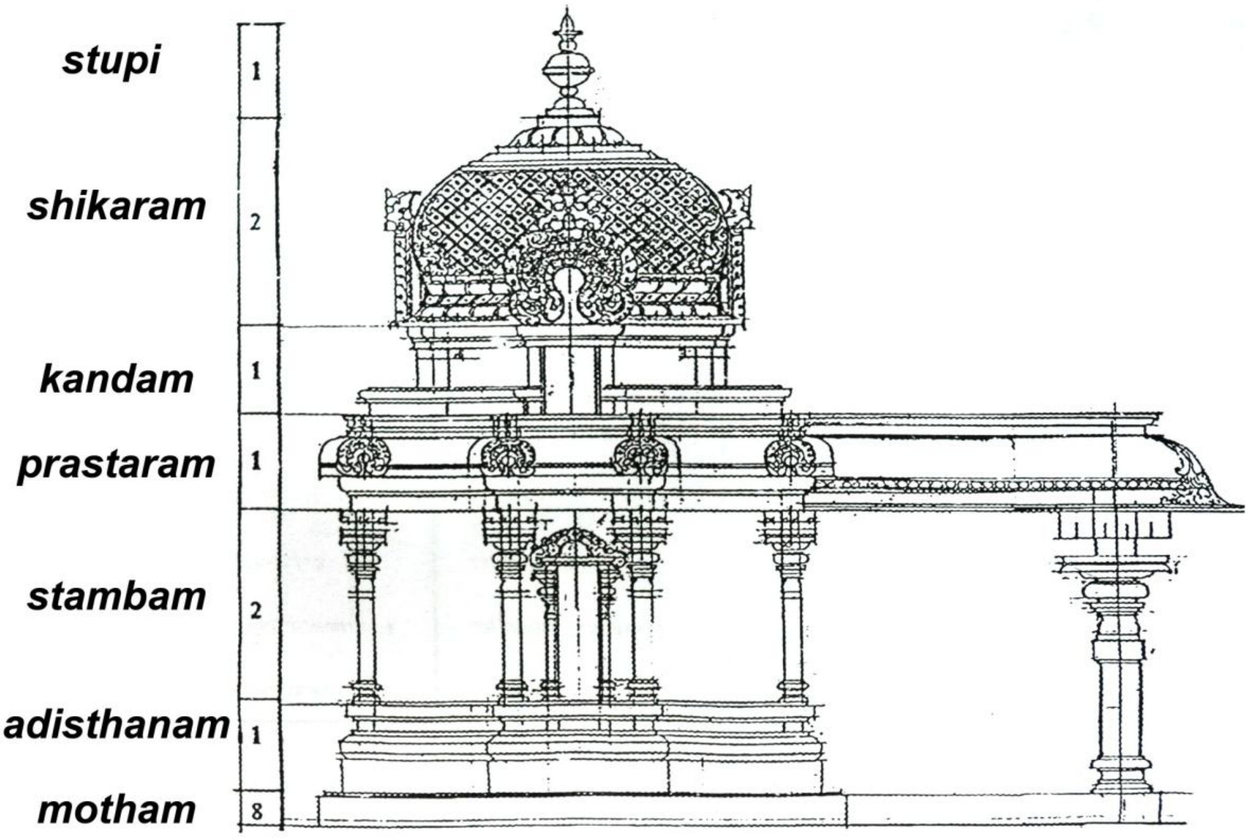


Figure 6 Parts of the Garba-griha and Vimana

Mandapas:

Mandapa means any roofed, open or enclosed pavilion (hall) resting on pillars, standing independently or connected to the sanctum of the temple. The basic Hindu temple will have a porch in front of the sanctum. The larger temples have one or more mandapa, the audience hall in front of the main sanctum. The mandapa may be closed or open with one two or three entrances.

There can be four types of mandapas. The first of the mandapas is the antarala (sometimes called sukanas or sukanasi or ardhamandapa), a narrow pavilion connecting the gharbhagriha and the navaranga. It usually will have niches in the exterior surfaces of the north and south walls, occupied by a deity, with attendant divinities in secondary niches flanking the central niche. In a few temples the antarala serves as the navaranga too.

The next mandapa is nrttamandapa or navaranga, is a big hall used for congregational services like singing, dancing, recitation of mythological texts, religious discourses and so on. The navaranga will usually be on a raised platform and will have nine anganas (openings) and sixteen pillars. This is followed by Sanapana mandapa, a hall used for ceremonial purposes. This leads to mukha mandapa the opening pavilion[21].

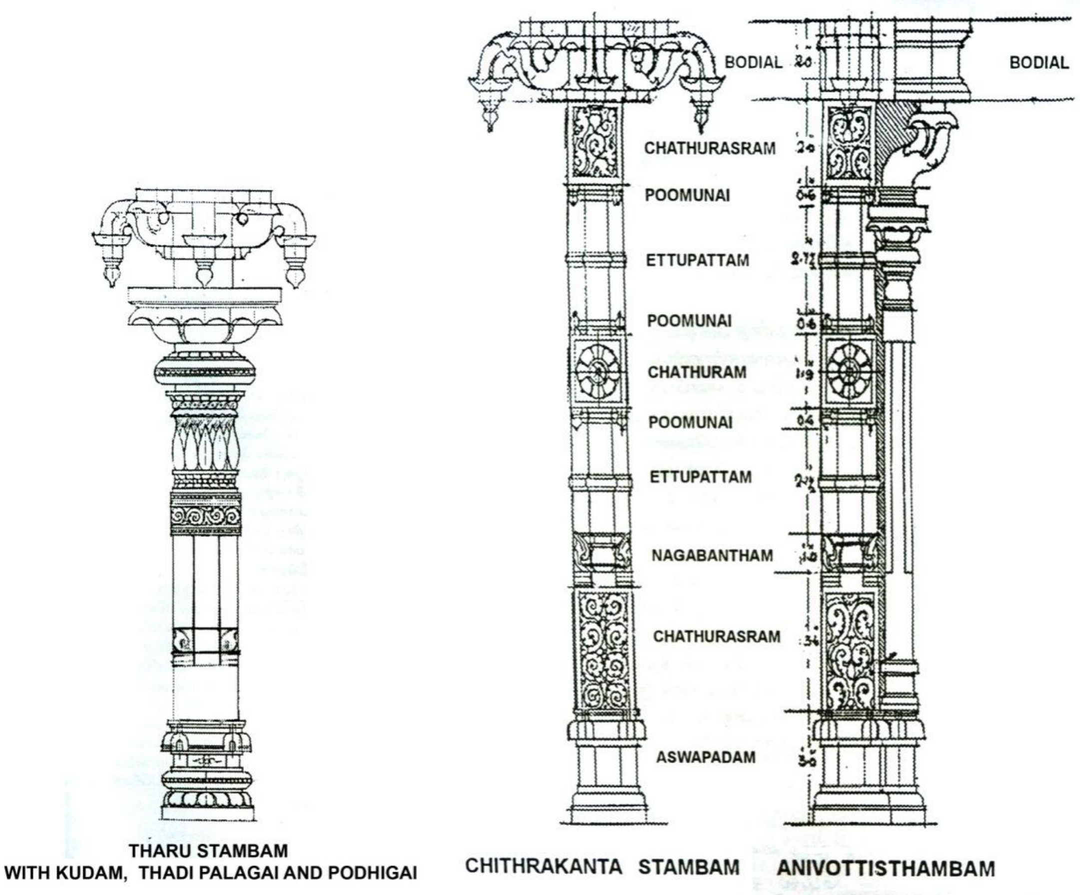


Figure 7 Parts of different types of Pillars

The Dwajasthambam or Kodimaram

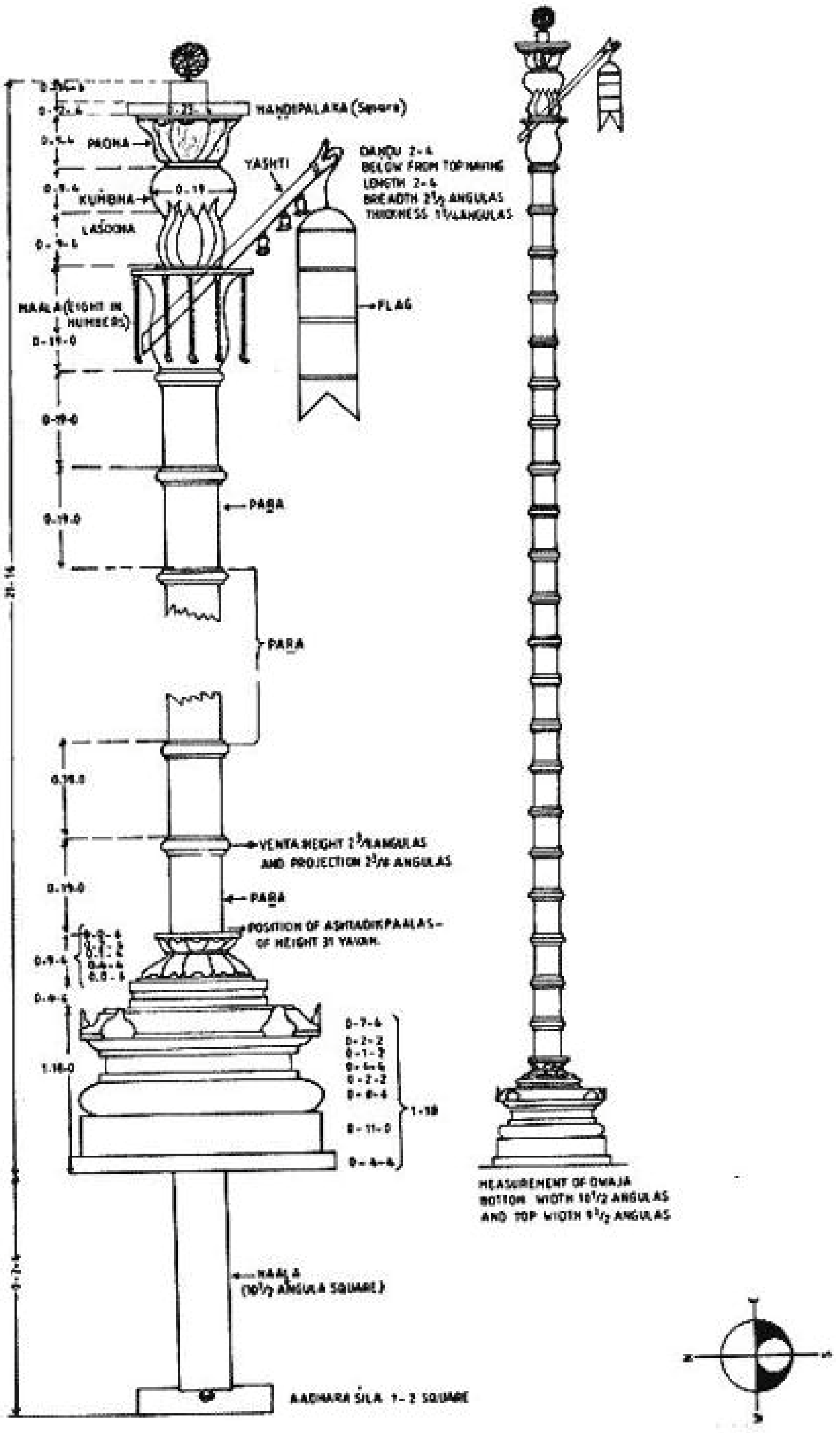


Figure 8 Flag staff or Dwajasthamba

The Dwajasthamba (flag post) in front of either the garbhagrha or antarala or the mandapa is another common feature. It should be perpendicular and directly opposite to the idol. The dwajasthambam is usually made of teak, while sandal wood, wood from beetle-nut tree may also be used. The height of the dwajasthambam must correspond to the hieght of the prasada of the garba-griha, the height of the stupi of the vimana or the height of the rajagopuram. The lanchana (insignia) made of copper or brass fixed like a flag to the top of the post varies according to the deity in the temple and his/her nature.

It will be located very close to the Bali pitha; and the Bali pitha will be between the sanctum and the Dwajasthamba. The figure on the lanchana is invariably that of the vahana (carrier vehicle) of the deity. For instance, in Siva temples it contains Nandi. In Devi temples it is the lion that finds its place. In Vishnu temples the Garuda gets that honour.

Bali pitha:

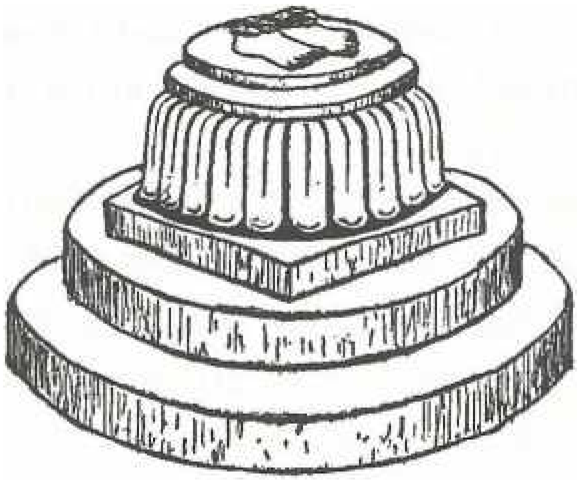


Figure 9 Bali peetha

Bali pitha is an indispensable associate of the sanctum. It is an altar or the dispensing seat of the deity. It is a small but stylized stone seat that is installed directly in front of the icon and very near the sanctum. It is the seat on which offerings to deity are placed.

The chief (pradhana) Bali pitha will be directly in front of the icon and often near the Dwajasthamba. It is usually made of hard granite and will be highly stylized, ornate, and majestic, with several limbs such as the base, cornices, wall-surface with door-lets or niches.

Raja Gopuram

In the case of major temples, the entire temple area is surrounded by a series of concentric protective walls, the prakaras. The lofty towers erected over the entrance gateways of these walls are the Gopuras.

A Gopura is generally constructed with a massive stone base and a superstructure of brick and pilaster. It is rectangular in plan and topped by a barrel-vault roof crowned with a row of finials. It differs from the Vimanam in that it need not necessarily be square-based. Above that rectangular base a pyramidal structure covered with brightly coloured plethora of sculpture is raised to a great height. A Gopura has to be towering and massive.

Symbolically, the Gopura and the entrance to the temple represent the feet of the deity. A devotes bows at the entrance, the feet of the Lord, as he steps into the temple and proceeds towards the sanctum, leaving behind the world of contradictions.

Kalasha

The peak of the Vimana, the Kalasha is at the centre of the Mandala. The crowning glory of the Vimana is its Kalasha, the vase. Interestingly, the Kalasa placed on top of the Vimana, it is said, is not imbedded into the structure by packing it with mortar or cement. It is, in fact, placed in position by a wooden member, *thanda* that juts out of the centre of the tower and runs through the vase, the Kalasha. It is around this tube that the lanchana 'tokens' (cereals and precious stones) are introduced. One of the explanations is the *thanda* represents the central channel of energy that connects to the centre of the garba griha.

B.6 STRUCTURAL SYSTEM OF THE TEMPLES

The distinctive architectural styles of Hindu temples have so developed due to broad geographical, climatic, cultural, racial, historical and linguistic differences between the northern plains and the southern peninsula of India[22]. Broadly based on geography, Hindu temples have been classified into three different orders; the Nagara or ‘northern’ style, the Dravidian or ‘southern ‘style, and the Vesara or hybrid style which is seen in the Deccan between the other two.

Most of these temples were constructed out of stone and promoted by the rulers themselves, on colossal scales. There were also other temples smaller in scale built by local communities using locally available materials.

The South Indian temples were predominantly built out of granite. However, there are exceptions such as the earliest structural temples belonging to the Pallava reign which were built with sandstone.

In the southern style of temples the history begins with the Early Chalukyas, and Kalchuris (6th to 8th century) and advanced to the Pallavas (7th to 8th centuries), the Rashtrakutas (8th to 10th century), the Cholas (10th to 11th century), the Hoyshalas and Later Chalukyas (11th to 14th century) and the Vijayanagas and the Nayakas(15th to 17th century[23]. The rock cut structures developed during the 7th -9th century under the rule of Pallavas. The Pallava rulers lead the way of Dravidian style of temple architecture and they built the temples at Mahabalipuram. During the Pandyas rule the south Indian temples were added with the lofty gateways gopurams at the entrance with the basic temple composition. The gopurams made the temple visually attractive and also provided the temples with an enclosure. The gopurams evolved from a rectangular base with a pyramid crowned with a barrel vaulted form. In the 11th century the Chola rulers built one of the tallest temples of that time the Brihadeshvara temple, Thanjavur with a height of 60 m[24]. In the later period the temples extended and became more intricate. More mandaps were included for various activities like dancing, assembly, eating, marriages, etc. The Dravidian style concluded in a series of extended temple cities or townships. The finest example of the temple township is the temple at Srirangam and Madurai with several concentric enclosures.

The basic construction technique used in the Hindu temple was the trabeated system or the post and the beam method and which was extended by the use of corbelling techniques[25].

Trabeated System

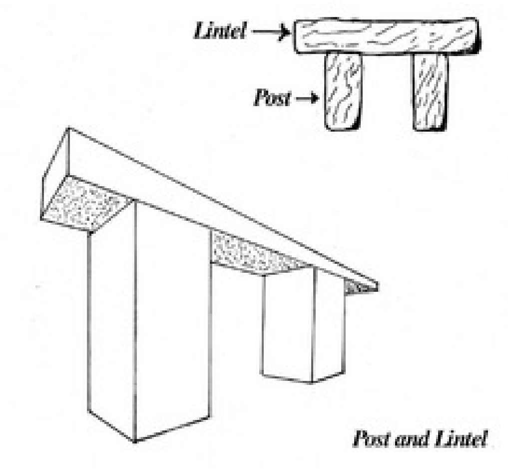


Figure 10 trabeated construction

Figure 11 trabeated construction in temples

In the trabeated system only the horizontal and the vertical members are used and the stability is achieved by the massive arrangements of vertical elements such as pillars and pilasters together and heavy cross beams and lintels. The use of the spanning system to enclose the interior spaces was the most typical feature of this system. The openings in the Hindu temple have lintel made of stone or timber. The roofing system consists of horizontally laid slabs of stone spanning from one supporting beam or wall to the other[26].

Corbelling System

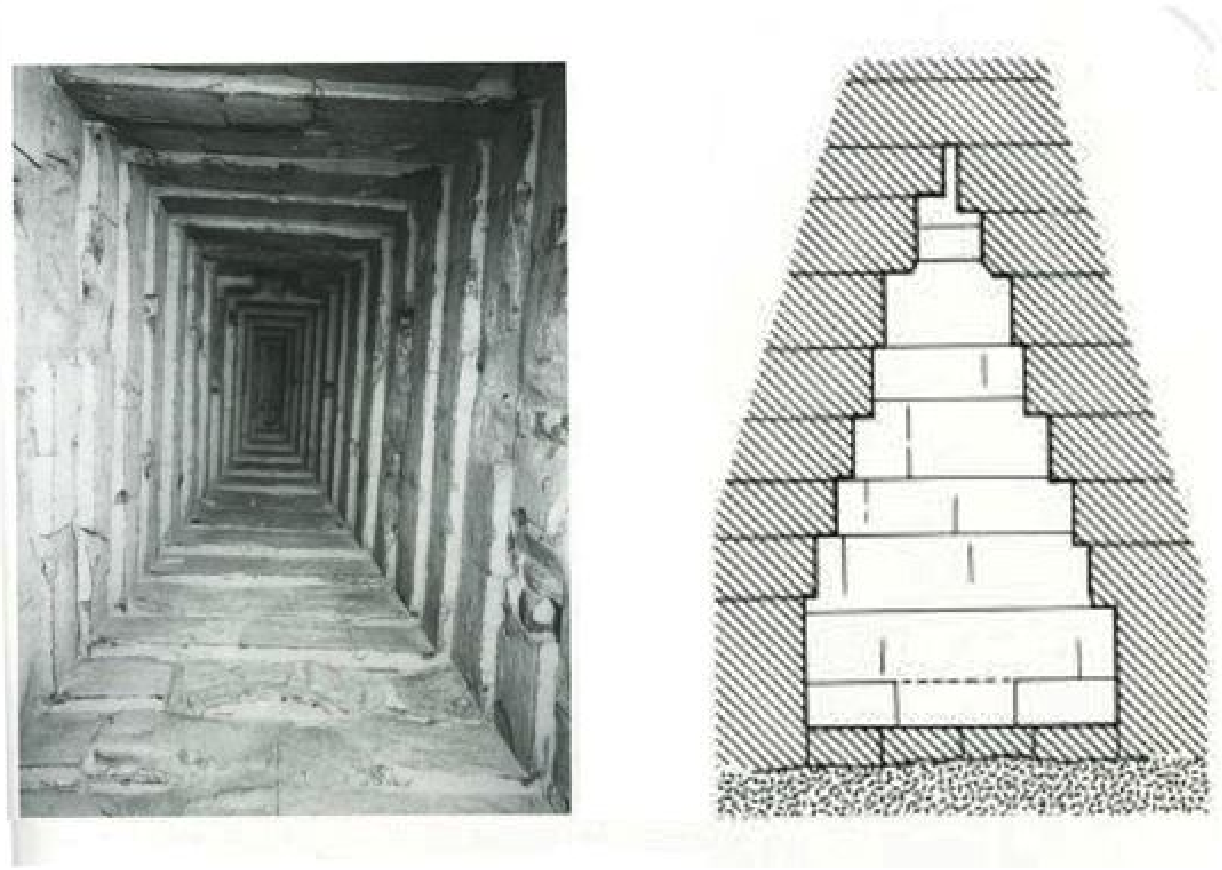


Figure 12 corbelling in stone constructions

In the corbelling system the stones or the bricks in each horizontal course are projected out to bridge the gap between the two walls to diminish until it can be closed with a single piece of stone or brick. The corbelling system was used to create the interiors of the temple and the stone shells of the super structure that riseabove the sanctuary, namely the vimana and the gopuram[27].

Brick Vaulting System

Vavval Nethi Mandapam:

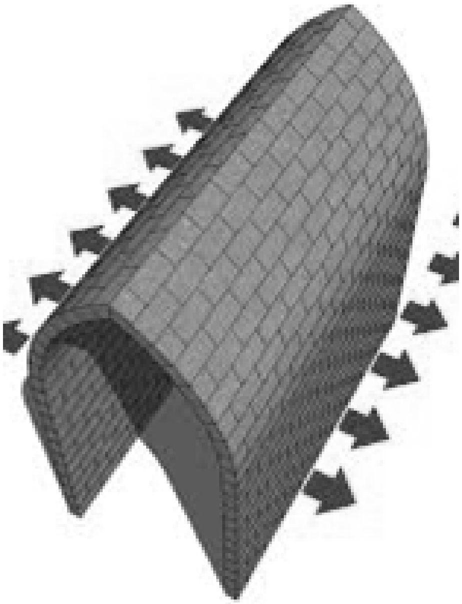


Figure 13 brick vaulting

Figure 14 brick vaulting in Sri Paalukandanadha Swamy Temple, Thiruvappadi

Mandapams that call for a central space with no supporting pillars, make use of the brick vaulting system for its roof structure. These are called Vavval nethi mandapam. Here, the lateral load of the roof is supported by flanking arches and columns or walls.

A groin vault or groined vault (also sometimes known as a double barrel vault or cross vault) is also commonly found in structures around Tanjore region.

This type of vaulting is produced by the intersection at right angles of two barrel vaults.

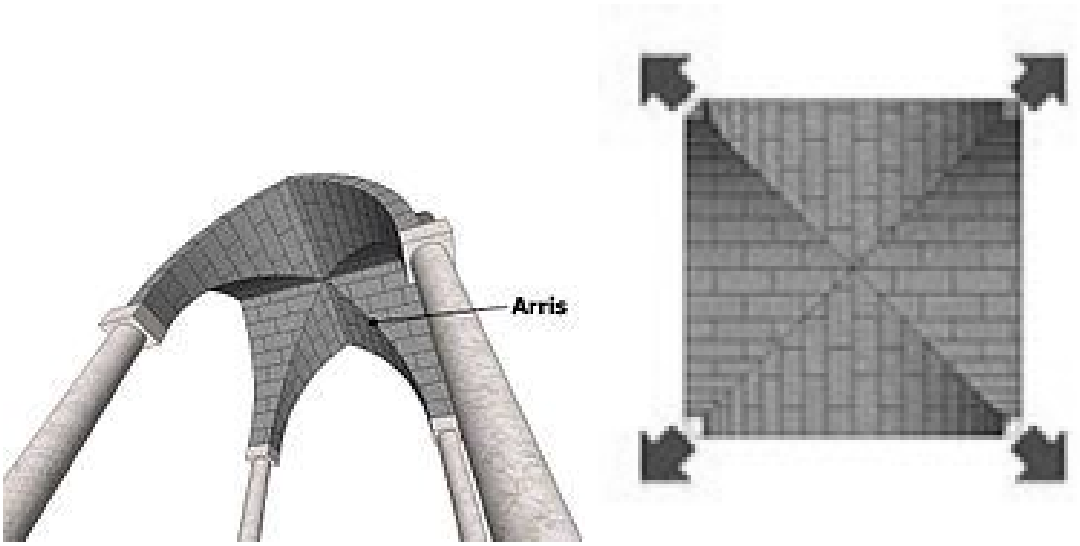


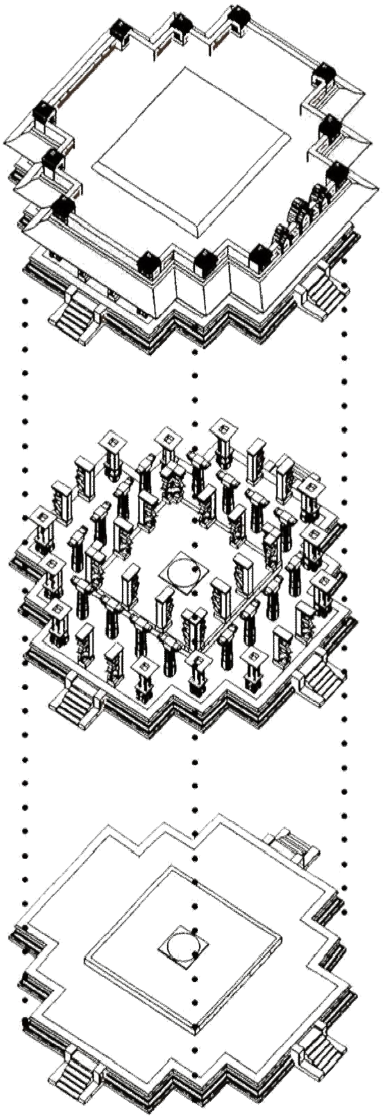
Figure 15 groin vault or cross vault

The construction of a groin vault can be understood most simply by visualising two barrel vault sections at right angles merging to form a squarish unit. The resulting four ribs convey the stress loading to the four corners, or piers.

B.7 ARCHITECTURAL FORMS IN TEMPLES

Mandapa or pillared halls (independent):

The basic Hindu temple will have a porch in front of the sanctum. The larger temples have one or more *mandapa,* the audience hall in front of the main sanctum. The mandapa may be independent or attached to the main shrine, closed or open with one two or three entrances



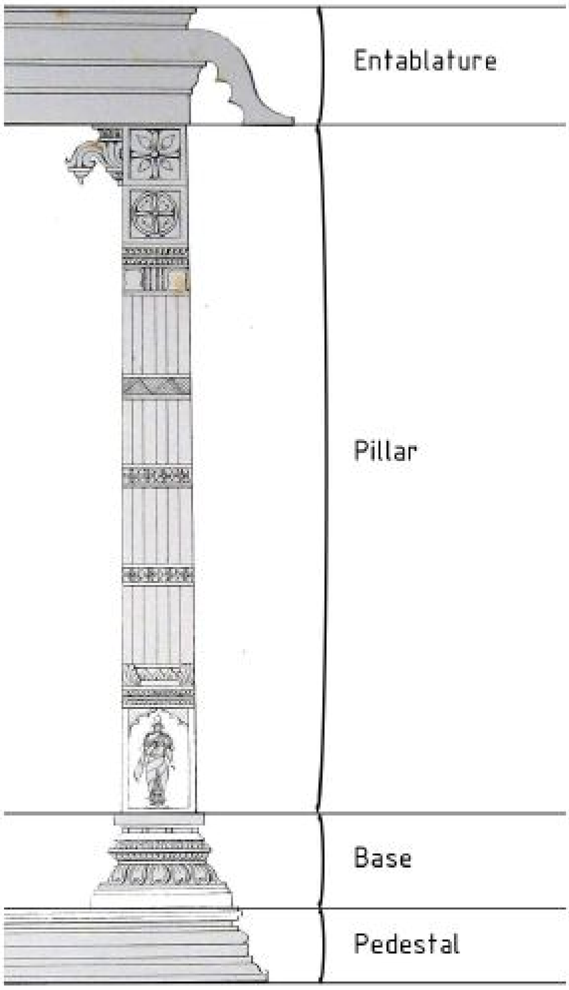


Figure 16 isometric view of mandapa **Figure 17 Order columns in temple architecture**

The Hindu order consists of four principal parts[28]:

- The upapítha or pedestal
- The athisthána or base
- The sthamba or pillar
- The prastára or entablature.

The entablature is topped by the parapet with ornate sculptural articulation.

The Foundation:

The stones are laid one above the other towards the structure boundary. As per classical texts the trench for the foundation is generally dug till it reaches the water table or rock. Hence, the depth of the foundation may differ from place to place.

Plinth:

The plinth stones placed above the foundation stones act as the retaining wall for the rubble compacted earth with in the plinth area of the structure. The stones of the plinth are place one above the other and they are stabilized by their self weight. The number of courses of stones at the plinth varies according to the size of the temple.

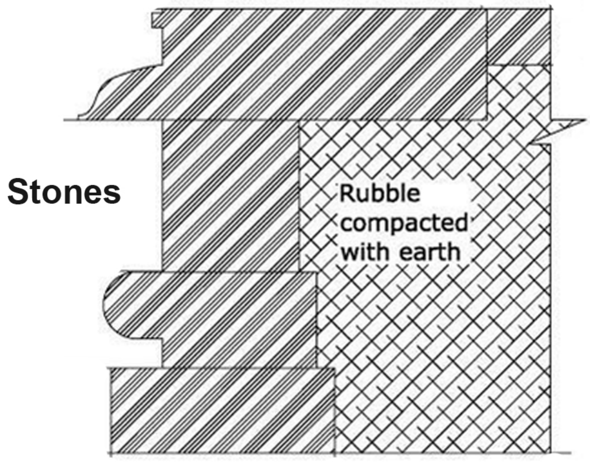


Figure 18 cross section od plinth

Columns:

The columns are monolithic structure. They are made up of 5 parts and all are interlocked by the mortise and tenon joints. The five parts consists of two parts of the

base one part as the shaft and two as the capital of the column. The top of the column is provided with brackets which provide a good bearing for the beams and reduce their spans.

Composite columns are variations of simple columns, in that, it is carved out of the same monolith but has one or many colonettes or figural sculptures projecting from the same stone. These projections maybe engaged to the core shaft or dis-engaged. While composite columns may consist of decorative and structural parts, they also have a structural role.

The capital projects in three directions, capital bracket support the beam, placed under one half of the beam; a massive projection forward from the capital, supports the secondary beam under the eave. The third projection from the capital, in direction of extends forward supporting the corbelled brackets above. This corbelled bracket (three corbels) supports the stone ceiling[29].

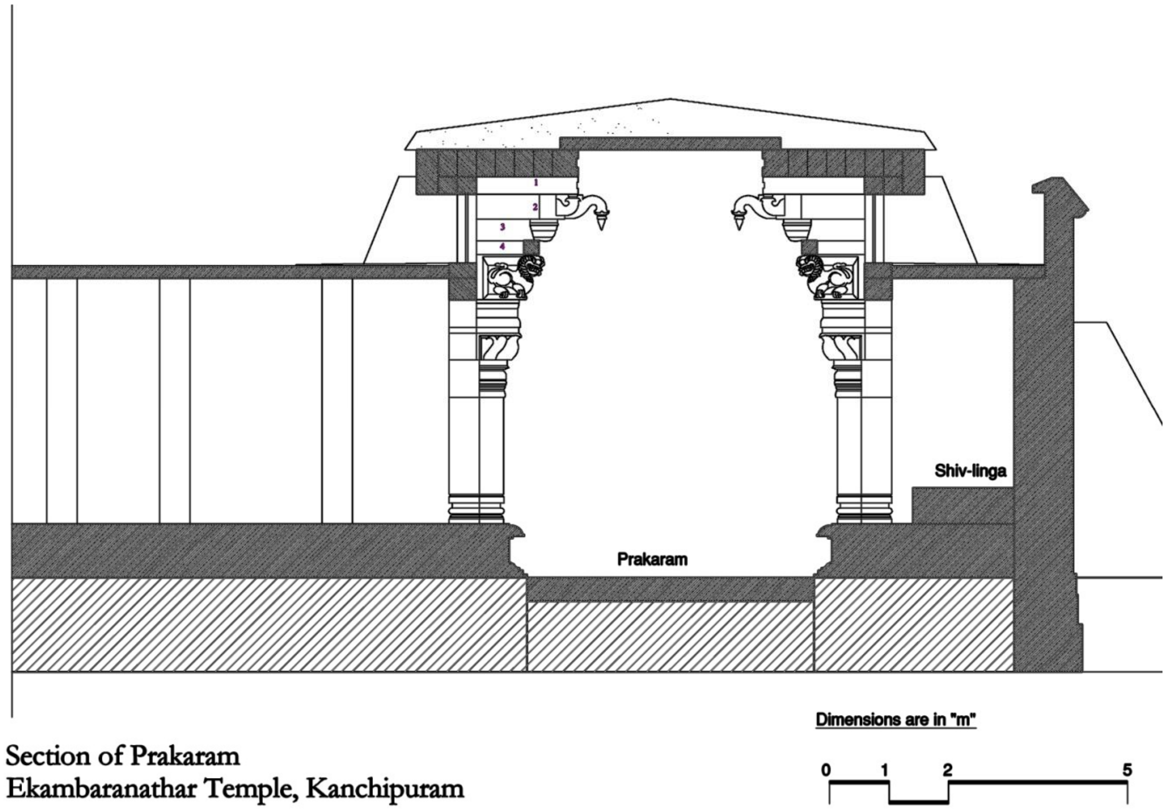


Figure 19 Section through column and roof structure of the prakaram

Figure 20 composite column in Meenakshi amman Temple, Madurai,

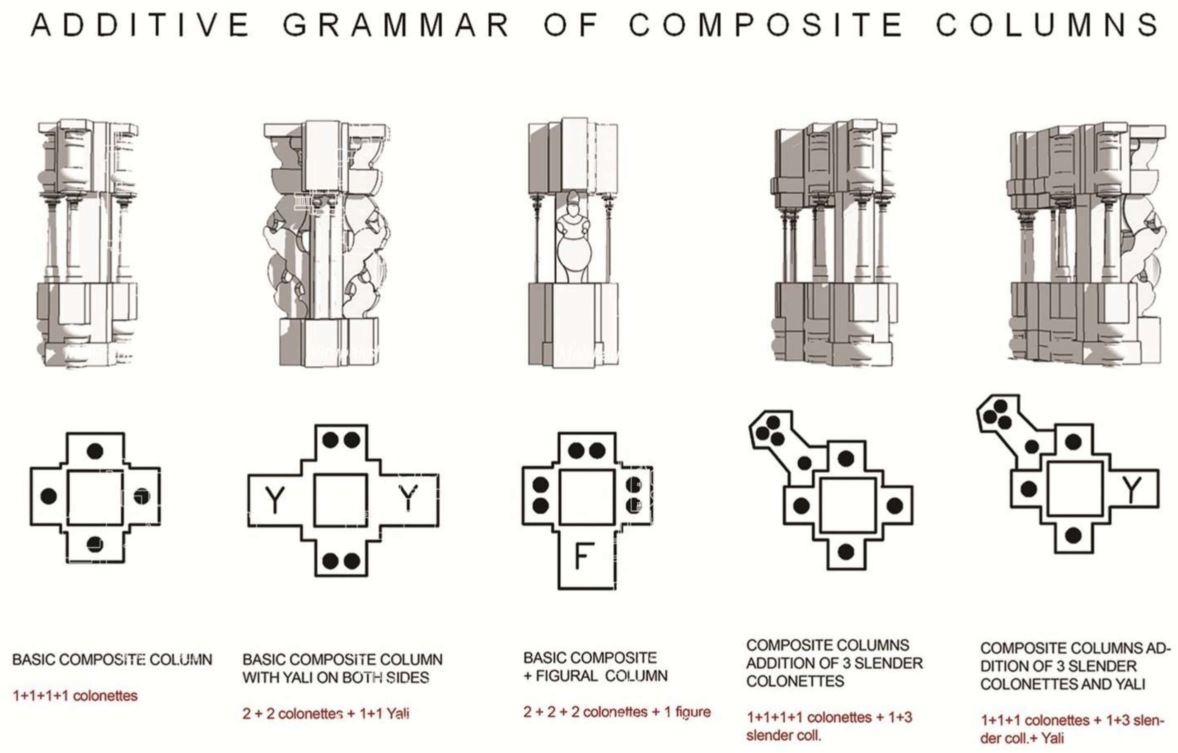


Figure 21 Different types of composite columns

Beams:

The beams are supported between the columns which in turn supports the roofing system of the temple. The mandapa of the temple may be flat roofed. The mandapa ceiling is built with basic beam and slab construction method[30].

The mandapa have flat roofs usually covered with massive stone slabs. They are typically dressed at the sides and bottom and topped with a layer of lime concrete to serve as water proofing. The spacing between the columns was determined on the basis bearing capacity, practicality of the quarrying and transportation.

While in the south the *mandapa* are provided with flatter pyramidal covering with waterproofing and surrounded by a parapet. The Mandapa in the south Indian temple are often large in size. (hundredpillar mandapa, thousand-pillar mandapa)

Pillared-halls with walled structures (small shrines):

The walls in the Hindu temple architecture are constructed as composite stone masonary with an infill of stone and brick with lime and mud. The main structural masonry walls are constructed as a stone composite masonry with stone, brick with lime or mud as the masonry core. Through stones are provided at regular intervals to strengthen the walls. The stone slabs are cut, dressed and carved and used for facing the earth filling or rock surface for the plinth. The joints are very fine either without any mortar or with fine lime mortar.

Mandapas with walled structures have stiffness irregularity in plan, the walled portion being stiff core compared to the trabeated portion, this is a potential zone for stress concentration.

Precinct walls (Prakaram walls):

Multi-leaf masonry with exterior ashlar and infill core with lime concrete (or other material) or random rubble masonry walls;

Most temples have multi-leaf walls which are composed by one or more external and internal leaves**.** External leaves contain stonework or brickwork and

internal leaves are usually made of rubble masonry or very weak infill materials, such as earth or loose material.

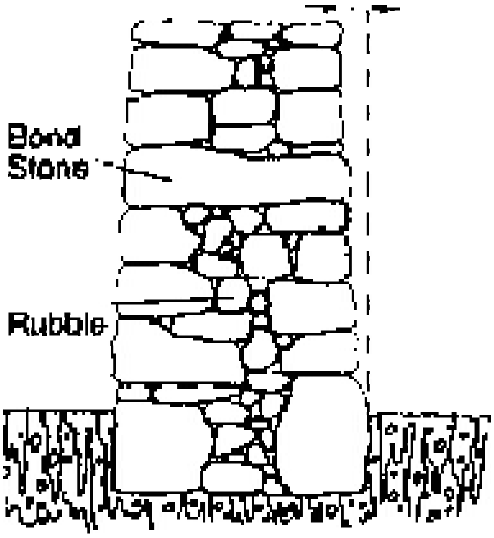


Figure 22 Interlocking in Ashlar Mosonry

Gopuram:

Entrance gateways with multi-leaf granite masonry with infill core (ground storey or kalkaram) and brick masonry upper stories; Madras terrace floors or timber floors and vaulted masonry roof; Foundations;

South Indian Gopuram has stone only in the lower story while upper storeys are made of brickwork and wooden beams. In addition to this the tower above becomes progressively narrower towards the top corresponding to the tiered divisions of the façade. This phenomenon resulted in the reduction of self weight of the structure, and improved stability due to the wider base. In Indian temples corners of the structure were provided with exceptionally large sections. The stones used at the corners are either interlocked or provided with iron clamps[31].

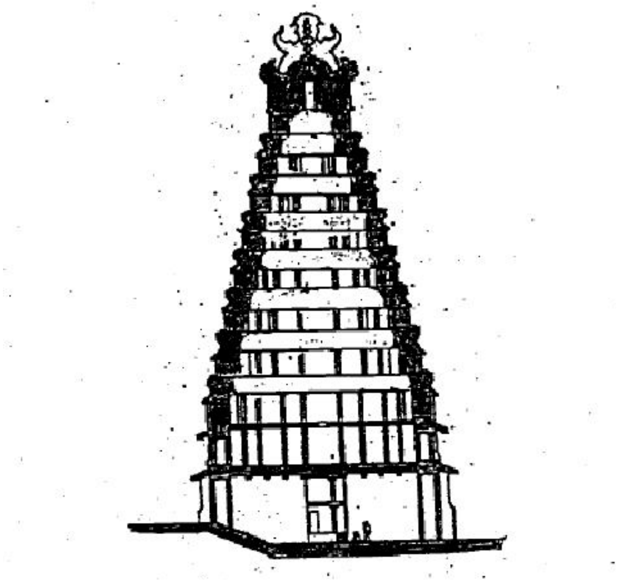


Figure 23 schematic section through corbelled superstructure.

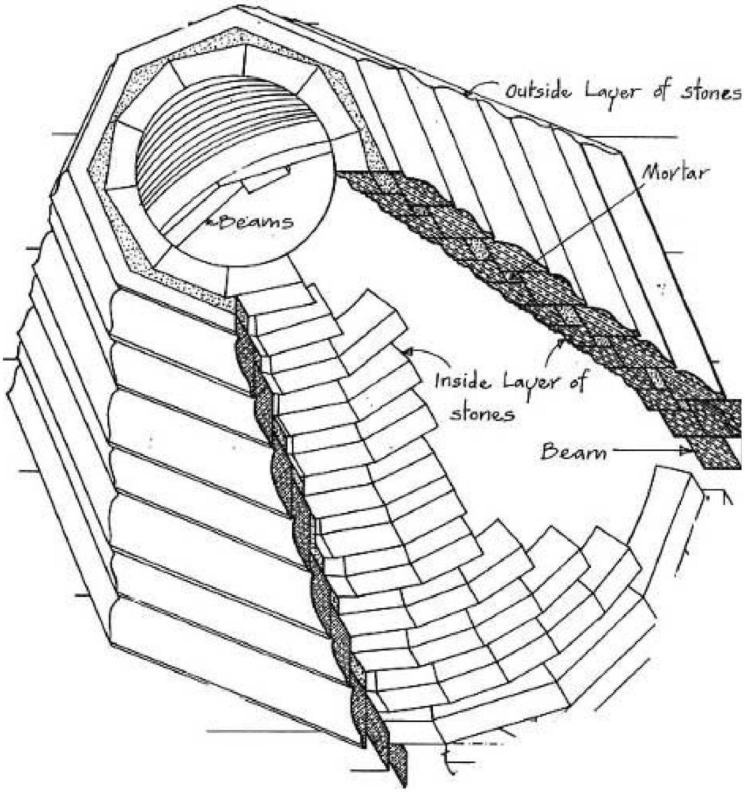


Figure 24 Stone corbelling construction

The superstructure of the Hindu temple relates to the spire or the sikhara of the temple. In the South Indian temple the super structure is that of the kutina and shala type. The super structure is pyramidical in form and consists of stepped

stories. The stepped structure is capped with a solid dome or cupola or with a barrel-vault roof. The structure is crowned with a pot and finial[32].

Shrines and vimana:

Foundations, plinth, stone masonry or brick masonry walls, corbelled vaulted or domed roofs.

The foundation below the sanctuary is generally fully packed with stones placed one above the other. At the base of the foundation on the exact centre of the garbha griha a hollow duct is placed running from the foundation base to the base of the main idol of the temple, for performing the ritual called as garbhadhana. The garba-griha may sometimes have one or more circumambulatory passages around it. In case of large temples the walls of these passages help support the corbelled roof structure while keeping the dimensions of the inner chamber small. These walls also have greater thickness for the same reason.

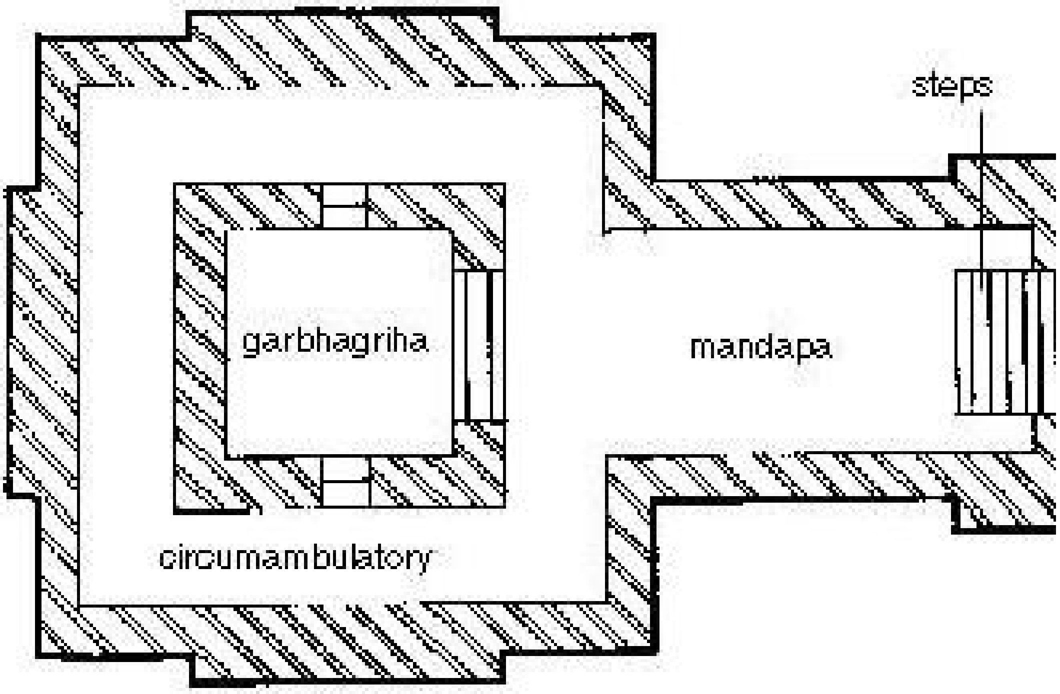


Figure 25 Typical plan of garba griha

Vimana

Vimana is the pyramidical structure built on the garbhagriha of the temple. Corbelling construction system is used for the construction of the vimana. The horizontal courses one above the other are stepped inwards and progressive forward to cover the space. The vimana is usually hollow from inside. The apex of the superstructure is mounted by a single piece of stone called as the stupi[33].

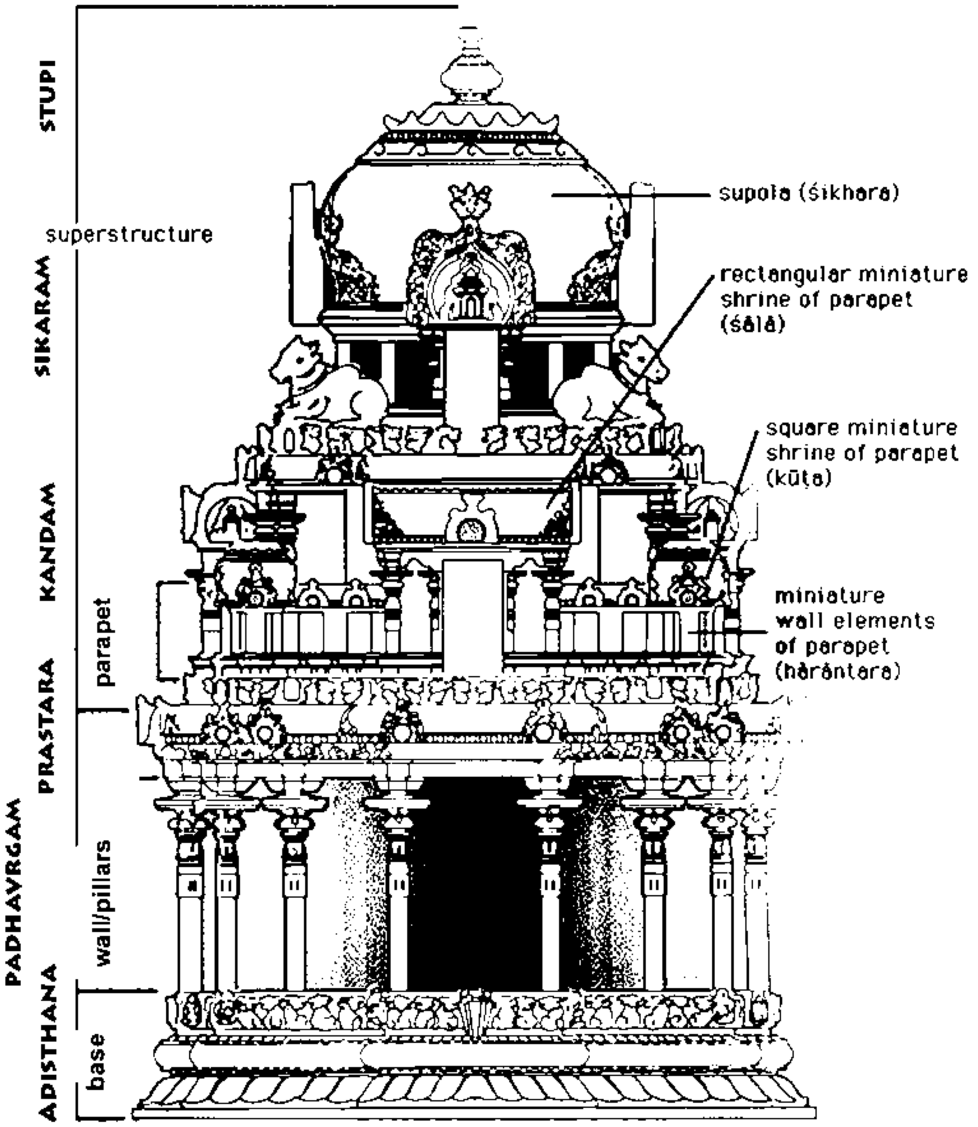


Figure 26 elevation of Vimana

C Factors causing deterioration of historic structures

Deterioration in historic structures can be defined as a defect in the material, component or finish which does not meet its accepted performance criterion. Technical knowledge and proficiency in engineering and construction are necessary to accurately recognize the root of building defects and the remedial measures essential to put the defects right.

Deterioration or decay in the foundation, floor, or wall can be the direct result of soil issues, water issues, or even workmanship issues. They require acquiring a professional evaluation of the situation, discovering the basis causes. An exact identification of a building defect necessitates knowledge and familiarity with the traditional practices of temple construction combined with an indulgent of methods of scientific exploration.

An accurate cause of a building defect and the form of its appearance must be understood prior to any remedial measures taken. This section of the manual discusses the important factors that affect the deterioration in temple structures.

C 1 Causes of Deterioration and Defects

The factors that affect building deterioration are of the following nature[34]:

C.1.1. Mechanical Agents:

These agents impose a physical force on a building. They maybe static and permanent such as ground pressure, or static and temporary. Alternatively, the force can be dynamic such as wind or vibration, so the design of the structural item must include mechanical agents, though failures still happen. Besides that, it is sometimes important to remember that non-structural components may also be subject to creep and deflection due to self-weight.

C1.2 Thermal Agents

Temperature is particularly relevant to components that are exposed to an unobstructed sky, for example roofing, cladding and external structural members. The actual temperatures reached can lead to either temporary or even permanent changes in physical or chemical properties, such as accelerated oxidation at high temperatures. Changes of the temperature are also relevant when assessing the consequences of thermal expansion and contraction – such as stresses within materials when changes of size are restrained and strains imposed on jointing materials when components are free to change size.

C1.3 Chemical Agents

Chemical agent that is most prevalent is water. It is probably also the agent with greatest influence on the properties of materials. In many instances the presence of moisture enables physical, chemical or biological reactions to take place. Examples are: 1) corrosion of iron and steel products 2) electrolytic corrosion between metals 3) fungal attack of on wood products. Most materials absorb moisture to some degree. The direct effect of water alone on a material can be) a volumetric change 2) a change in mechanical properties 3) a change in appearance. Building failures can also be caused by dampness from the ground.

C1.4 Biological Agents

Biological agents can be divided into four categories;

i. Surface growths - These include bacteria, fungi, algae, lichen and mosses. They do not necessarily harm but some release acidic metabolic products which are corrosive, and other invade the surface of substrata and cause deterioration.

ii. Insect vermin - The predominant damage or deterioration to construction materials caused by insects occurs with timber and timber based products.

iii. Animal vermin - The pests most likely to harm building materials are rats and mice, who gnaw timber. Burrows and displacement of sand by the activity of rats can lead to blockage of the traditional water drainage system.

iv. Plant agents - Probably the major damage to building are from tree roots disrupting foundations and penetrating underground drains. Damage to building from plants has also been caused by plants growing in cracks in the masonry, thus widening the cracks as well as plants growing in gutters and blocking them.

C1.5 Earth Movement

Whenever the water contents are lost from the soil, the earth or soil particle will be prone to combine together or it will be compacted. Usually clay soils are prone to make a big movement due to its natural moisture absorbance and liquid can freely flow.

The changes of moisture in earth particles could lead to changes in the loading of the structures. Water in soil is usually driven out leaving the particle to combine together. If the soil underneath a building is compacting or joining together, the foundation could sink until the soil is balanced.

C.2 Weathering of Stone Heritage Structures in India

Depending upon the climatic condition of the region where these stones are present, environmental agencies play a role in their deterioration. However, the extent of decay also depends on whether the stone is present inside or outside. Usually, the rate of decay is more outside than inside because of the action of different deteriorating agencies.

The factors responsible for the deterioration of stone in Indian monuments can be broadly categorized as chemical weathering, physical weathering and biological weathering; they never affect the heritage structures in isolation. The common problems faced by Indian stone monuments[35] are as follows:

1. Surface erosion – As a building is in the open and is exposed to the sun, the rain and the wind, its exterior surface gets eroded and quite often pitting is formed on it.

2. Effect of sea breeze – The heritage structures located on the coast face this problem. The classic examples are those of the Shore temple at Mahabalipuram, Tamilnadu. Apart from erosion by the sea breeze, the stone gets saturated with salts on account of salt contained in the air.

3. Exfoliation of stone layers – The layers of stone, particularly of the sedimentary rock-like sandstone separate and split.

4. Formation of cracks – Cracks of various dimensions develop in stones of all types.

5. Control of micro-organisms – India, with a tropical climate, having rainfall and plenty of moisture, the growth and development of different types of micro-organisms on stone is very natural. These micro- organisms grow very quickly and cover the surface of the heritage structures.

C 2.1 Mechanisms of Stone Decay

"Before we can take any action to prevent or to remedy the deterioration of stone, we must understand what is causing it. Sometimes, the cause is obvious; sometimes there may be several different causes acting at once"[36]. The causes for the deterioration of building stone in general, are summarized as follows:

i) Dampness: Water is an essential factor in the generation of internal stresses. Water exerts mechanical action during driving rain, storm and freezing. It penetrates a porous stone by means of capillary absorption. Water laden with salts is transported in stone through capillaries. The rate of leaching is greatest for stones with high porosity. On a moist stone surface the rate of deposition of pollutants is high compared to that on a dry surface. Water in various forms is involved in various types of stone deterioration.

ii) Salt attack: Soluble salts can be originally present in stone before its incorporation into the building or can be derived from external sources such as soil, atmosphere,

pointing materials or wrong interventions during cleaning and maintenance. In the presence of moisture and thermal ingredients, these salts migrate towards warmer parts. The dissolved salts in the moisture turn into crystals after evaporation called crystallization. Soluble salts may crystallize on the surface of the stone forming unsightly deposits known as efflorescence. The salt crystals form and grow in the pores and exert forces on the surrounding stone known as crypto-florescence or sub-florescence. The most common salts occurring in efflorescence are sulphates, chlorides, nitrates and carbonates.

iii) Decay due to thermal variations: Stresses are developed in building stones due to thermal changes and diurnal variations. Most of the rocks are poly-minerallic in nature; each mineral expands in different rates, thus setting up minor stresses and strains which tend to pull apart the minerals and disrupt the rocks. Sudden cooling of the outer surface during rain causes a strain between the outer and inner portions of the rock elements in buildings, which results in disintegration.

iv) Decay due to atmospheric pollution: As various atmospheric pollutants are present simultaneously, it is difficult to point out the effect of one pollutant and no pollutant acts in isolation. Hence the decay due to the pollutants is complex. Carbon monoxide, ammonia, hydrogen chloride, hydrogen sulphide, ozone, particulate matter and sulphur oxides are the common harmful atmospheric pollutants.

v) Bio-degradation of stone: Algae, moss and lichens are commonly found on damp stone surfaces. The growth becomes rapid immediately after rainfall, showing up bright green in colour and becomes dry imparting a dark appearance. Acids generated from moss and lichens leads to damage of stone. Growth of small plants and vegetation causes physical stresses due to propagation of roots; further, the roots penetrate the joints and lead to cracks. Dampness is retained on the stone due to the presence of vegetation thus inducing continuous damage.

vi) Decay due to quarrying and dressing: The micro cracks formed during the quarrying of stones lead to the entry of salt and acid solutions.

An effective conservation method can be adopted with diagnostic studies which may include Geo-technical Survey, Material Analysis and Mapping of Structural Distresses. These investigations must be done with minimal intervention to the structure using 'Non-Destructive Testing Techniques' wherever possible.

C 3 Historic Masonry Deterioration Problems[37]

C3.1 Chipping

Small pieces or larger fragments of masonry separating from the masonry unit are found often at corners or mortar joints. This may be the result of damage caused by later alterations or repairs, such as use of too hard a mortar, or by accident or through vandalism.

Figure 27 Damage in the capital , Ekambaranathar temple, Kanchipuram

C 3.2 Cracking

A term describing narrow fissures from 1/16 to 112 inch wide in a block of masonry. Cracking, may result from a variety of conditions, such as structural settlement of a building, too hard a repointing mortar, or it may be an inherent characteristic of the masonry itself. Small cracks within a single block of masonry may not be serious, but longer and wider cracks extending over a larger area may be indicative of structural problems, and should be monitored.

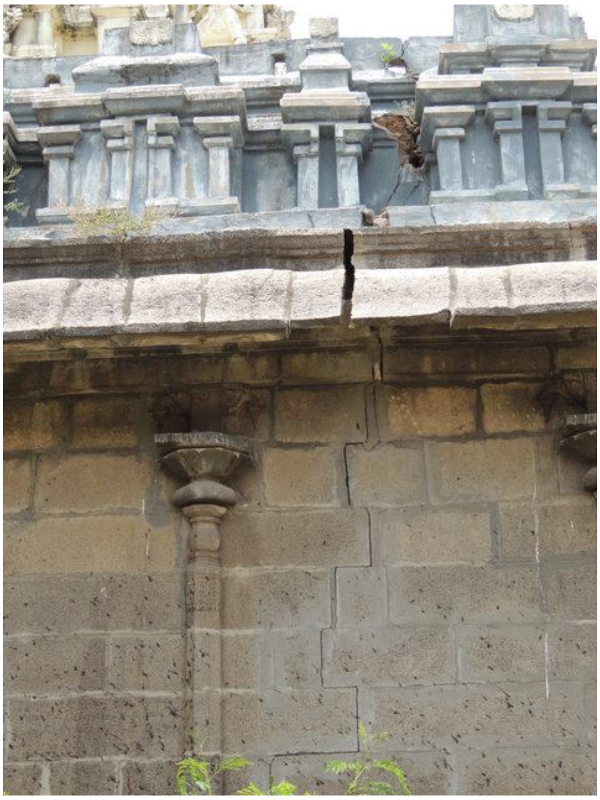


Figure 28 Cracking in wall and roof, Ekambaranathar temple, Kanchipuram

C 3.4 Crumbling

This condition is indicative of a certain brittleness or tendency of the masonry to break up or dissolve. It may be caused by an inherent weakness of the masonry and gradual dissolution of the binder, or it may be the result of external factors affecting the strength or durability of the masonry, such as salts or moisture entering the masonry.

Figure 29 crumbling of masonry walls in Srirangam

C 3.5 Delamination

A condition of stone in which the outer surface of the stone splits apart into laminae or thin layers and peels off the face of the stone. Because of their layered composition, this may be a natural condition of sedimentary stones such as sandstone or limestone; and the presence of clay-rich layers can accelerate the process.

When sedimentary stones are used in building, this tendency to peel off in layers can be exacerbated by improperly laid stones. Delamination takes place along the natural bedding planes of the stones when they are laid vertically, instead of horizontally-the correct way-and, as a result, are exposed to weathering.

Figure 30 flaking of layers in sandstone, in Kailasanathar temple, Kanchipuram

C 3.6 Detachment

The result of a complete break (or failure of an original construction joint) in which the detached portion of masonry survives intact.

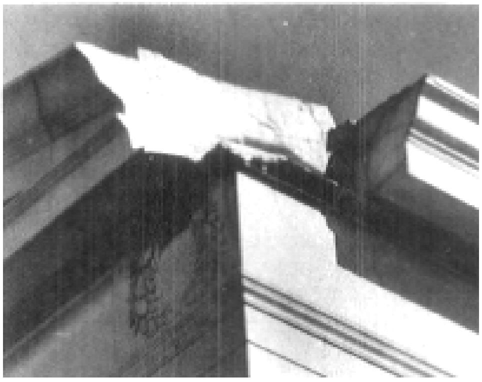


Figure 31 Detachment of parts in stone construction

C 3.7 Weathering

The natural disintegration and erosion of stone caused by wind and rain, resulting in granular and rounded surfaces. Weathering is particularly pronounced on sharp corners, or highly carved or projecting architectural details.

Acid rain water in particular, in contact with acid soluble, carbonate stone, can be very damaging, increasing the natural weathering rates, and also resulting in noticeable softening or loss of masonry details.

Honeycomb or alveolar weathering is a type of erosion common to sandstones and lime stones, and other non-homogeneous masonry materials. It is characteristic of arid climates, but may also be found in more humid areas. Cavities (alveoles) are created in a honeycomb pattern on surfaces exposed to strong winds where evaporation of salts occurs directly below the surface.

Figure 32 honeycombing in plinth level due to erosion, Kailasanather temple, Kanchipuram

C 3.8 Efflorescence

A whitish haze of soluble salts on masonry generally caused by excessive "pulling" of soluble salts into the masonry and out through the surface. Capillary action may pull soluble salts which result in efflorescence from the ground into the masonry. In addition, carbonates from lime mortar and air-borne or water-deposited pollutants in the atmosphere may cause sulfates to be deposited on the surface of the masonry.

Efflorescence itself may be more unsightly than harmful, but its presence on an older or historic masonry building often serves as a warning, indicating that water has found a point of entry into the structure. Once this has occurred, more serious damage can usually be predicted

Figure 33 Efflorescence in stone surface

LIST OF FIGURES AND SOURCES

Figure 1 The Vaastu Purusha Mandala 15
V. Ganapati Sthapati, *Building Architecture of Sthapatya Veda, 2nd Edition*, Dakshinaa Publishing House, Chennai, 2005.

Figure 2 Significance of Directions and placement of Dieties 16
G.Venkatramana Reddy, Alayam: The hindu temple: epitome of Hindu culture, Sri Ramakrishna Math Publications: 2010

Figure 3 Vertical arrangement of spatial forms in the temple and its relation to the human form 18
Alaya Nirmana Binba Lakshana, M.Muthiah Stapathi, HR&CE Publications

Figure 4 The temple and its relation to the human form in plan 19
G.Venkatramana Reddy, Alayam: The hindu temple: epitome of Hindu culture, Sri Ramakrishna Math Publications: 2010

Figure 5 Succession of Rajagopuram in Ranganathaswamy temple, Srirangam 24
cited in various online sources including, http://www.indstt.com/ Indian Society for Trenchless Technology

Figure 6 Elements of the temple 37
G.Venkatramana Reddy, Alayam: The hindu temple: epitome of Hindu culture, Sri Ramakrishna Math Publications: 2010

Figure 7 Parts of the Garba-griha and Vimana 39
Alaya Nirmana Binba Lakshana, M.Muthiah Stapathi, HR&CE Publications

Figure 8 Parts of different types of Pillars 40
Alaya Nirmana Binba Lakshana, M.Muthiah Stapathi, HR&CE Publications

Figure 9 Flag staff or Dwajasthamba 41
http://kadavuleh.blogspot.in/2012/04/temple-dwaja-sthampam.html

Figure 10 Bali peetha 42
www.hindupedia.com
Figure 11 trabeated construction 45
www.studyblue.com

Figure 12 trabeated construction in temples 45
photograph available with the HR&CE Department

Figure 13 corbelling in stone constructions 46
www.sompura.com cited in Shweta Vardia Building Science of Indian Temple SAHC 2007-2008 Universidade do Minho Advanced Masters Thesis in Structural Analysisof Monuments and Historical Constructions

Figure 14 brick vaulting 47
Wikipaedia

Figure 15 brick vaulting in Sri Paalukandanadha Swamy Temple, Thiruvappadi 47
veludharan.blogspot.com

Figure 16 groin vault or cross vault 48

source: Wikipaedia

Figure 17 isometric view of mandapa Figure 18 Order columns in temple architecture........... 49
fig 17. By the Author, fig 18, K. J. Oijevaar The South Indian Hindu temple building design system On the architecture of the Silpa Sastra and the Dravida style, Delft University of Technology, The Netherlands, 2007

Figure 19 cross section of plinth... 50
Shweta Vardia Building Science of Indian Temple SAHC 2007-2008 Universidade do Minho Advanced Masters Thesis in Structural Analysisof Monuments and Historical Constructions

Figure 20 Section through column and roof structure of the prakaram 51
Measured Drawing courtesy Architect.Hareesh Haridasan, NCSHS

Figure 21 composite column in Meenakshi amman Temple, Madurai, ... 52
photograph available with the HR&CE Department

Figure 22 Different types of composite columns.. 52
Illustration by Author

Figure 23 Interlocking in Ashlar Mosonry 54
Voulme 5, Repair and Strengthening of Reinforced Concrete, Stone Masonry and Brickmasonry buildings, United Nations Industrial Development Organization, United Nations Development Programme, Vienna, 1983

Figure 24 schematic section through corbelled superstructure. 55
Figure 25 Stone corbelling construction 55
Shweta Vardia Building Science of Indian Temple SAHC 2007-2008 Universidade do Minho Advanced Masters Thesis in Structural Analysisof Monuments and Historical Constructions

Figure 26 Typical plan of garba griha 56
Shweta Vardia Building Science of Indian Temple SAHC 2007-2008 Universidade do Minho Advanced Masters Thesis in Structural Analysisof Monuments and Historical Constructions

Figure 27 Elevation of Vimana 57
Alaya Nirmana Binba Lakshana, M.Muthiah Stapathi, HR&CE Publications

Figure 28 Damage in the capital , Ekambaranathar temple, Kanchipuram 63
photograph by Hareesh Haridasan, NCSHS

Figure 29 Cracking in wall and roof, Ekambaranathar temple, Kanchipuram.................................... 64
photograph by Hareesh Haridasan, NCSHS

Figure 30 crumbling of masonry walls in Srirangam 65

- Photograph cited in article in The Hindu, by M. Balaganessin

Figure 31 flaking of layers in sandstone, in Kailasanathar temple, Kanchipuram.............................. 65
Jayanthi D, Conservation of *sandstone monuments at Kanchipuram Tamilnadu India*; · 2014, Phd Thesis, School of Architecture and Planning, Anna University
Figure 32 Detachment of parts in stone construction.. 66
Jayanthi D, Conservation of *sandstone monuments at Kanchipuram Tamilnadu India*; · 2014, Phd Thesis, School of Architecture and Planning, Anna University

Figure 33 honeycombing in plinth level dure to erosion, Kailasanathar temple, Kanchipuram 67

Jayanthi D, Conservation of *sandstone monuments at Kanchipuram Tamilnadu India*; · 2014, Phd Thesis, School of Architecture and Planning, Anna University

Figure 34 Efflorescence in stone surface 67

Jayanthi D, Conservation of *sandstone monuments at Kanchipuram Tamilnadu India*; · 2014, Phd Thesis, School of Architecture and Planning, Anna University

---

[1] Patrick.J.Faulkner, India, The Renovation And Conservation Of Temples In South India With Particular Reference To The Temple Of Sri Ranganathaswami, Srirangam, Madras, UNESCO, Paris, 1966

[2] Early Indian Architecture and Art Subhash Kak, Migration & Diffusion - An international journal, Vol.6/Nr.23, 2005, pages 6-27

[3] Vistara – The Architecture of India, Catalogue of the Exhibition, edited by MN Ashish Ganju and Carmen Kagal, 228-231

[4] Building architecture of Stha-patya Veda,Ganapathi Stapathi. Dakshinaa Pub. House. *2005*.

[5] *Devalaya Vastu*, By Prof. SKR Rao
http://www.britannica.com/dday/print?articleId=109585&fullArticle=true&tocId=65333

[6] Notes from Padmashri.Muthiah Stapathi see appendix

[7] *Devalaya Vastu*, By Prof. SKR Rao from Vastu Darshan by Dr. G Gnanananda.

[8] Inputs from Dr.Dayalan, A.S.I for the conservation manual

[9] Notes form Padmasri Muthiah Stapathi see appendix

[10] Building materials of ancient India, Dr.A.S.Nene,
http://www.slideshare.net/ashoknene/building-materials-of-ancient-india

[11] G.Venkatramana Reddy, Alayam: The hindu temple: epitome of Hindu culture, Sri Ramakrishna Math Publications: 2010

[12] The Cosmological View of Mamuni Mayan in His Mayonic Science by Dr.Jessie J. Mercay

[13] Ramachandra Rao, S.K, Art and Architecture of Indian Temples, Vol. I, UBS Publishers, Distributors Ltd., Bangalore, 1993

[14] Ramachandra Rao, S.K, Art and Architecture of Indian Temples, Vol. I, UBS Publishers, Distributors Ltd., Bangalore, 1993

[15] ibid pp. 3-49

[16] ibid p.48.

[17] ibid p.83
[18] ibid p.174

[19] *Kumara Thandiram, published by Thandayuthapani thirukoil, Palani: 2003*

[20] Alaya Nirmana Binba Lakshana, M.Muthiah Stapathi, HR&CE Publications

[21] [21] *Devalaya Vastu*, By Prof. SKR Rao
http://www.britannica.com/dday/print?articleId=109585&fullArticle=true&tocId=65333

[22] Shweta Vardia Building Science of Indian Temple SAHC 2007-2008 Universidade do Minho Advanced Masters Thesis in Structural Analysisof Monuments and Historical Constructions

[23] Brown, Percy. 1942. Indian Architecture:Buddhists and Hindu Period. Bombay: Taraporevala & Sons.

[24] Hardy, Adam. 2007. The Temple Architecture of India. Great Britain: Wiley.

[25] Shweta Vardia Building Science of Indian Temple SAHC 2007-2008 Universidade do Minho Advanced Master's Thesis in Structural Analysisof Monuments and Historical Constructions

[26] Michell, G. 1988. *The Hindu Temple: An Introduction to its Meaning and Forms.* Chicago and London:The University of Chicago Press..

[27] *ibid*

[28] Ráz, Rám. *Essay on the Architecture of the Hindús.* London: John William Parker, West Strand, 1834.

[29] 3 An understanding of the composite columns is based on the format of study employed by Filliozats in describing the *Mahamandapa* in: Filliozat, Pierre-Sylvian Filliozat and Vasudhara. Hampi-Vijayanagar: The Temple of Vithala. New Delhi: Sitaram Bharatiya Institute of Scientific Research, 1981.

[30] Hardy, Adam. “Tradition and Transformation: Continuity and ingenuity in the Temples of Karnataka.” *The Journal of the Society of Architectural Historians, Vol. 60, No. 2*, June 2001: 180- 199.

[31] Vasudha A. Gokhale, Architectural Heritage And Seismic Design With Reference To Indian Temple Architecture 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004

[32] Acharya V.A,"Indian Temple Architecture: form and Spaces" Research Paper, Department of Architecture & Planning, I.I.T .Roorkee, Roorkee, India, 1991

[33] Shweta Vardia Building Science of Indian Temple SAHC 2007-2008 Universidade do Minho Advanced Masters in Structural Analysis of Monuments and Historical Constructions

[34] Barry Richardson, Defects and Deterioration in Buildings: A Practical Guide to the Science and Technology of Material Failure, Routledge, 2002

[35]*Agarwal* O.P. 'Stone Conservation and Future Research – An Indian Perspective', Special Volume on Conservation of Stone Objects, Jeyaraj V. (ed.), The Government Museum, Chennai: 2003

[36] Price C.A, 'Stone Conservation – An Overview of Current Research', Research in Conservation Series, Getty Conservation Institute, USA:1996

[37] Anne E. Grimmer, A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments, Department of the Interior National Park Service Preservation Assistance Division, 1984